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CRYSTALLIZATION PHENOMENA IN VOLCANIC EJECTA FROM KILAUEA, HAWAII

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ABSTRACT

Blocks of glass-bearing basalt, ejected from Kilauea volcano during the explosive eruption of 1924, contain principally microphenocrysts of olivine and variolitic structures composed of labradorite and augite, with a considerable quantity of interstitial basaltic glass. The texture of the rock and the paragenetic relations of its minerals evince three distinct stages of congelation.

INTRODUCTION

The eruption of Kilauea volcano on Hawaii in May 1924 was of particular interest because it involved many violent explosions, phenomena not common to Kilauean activity. In fact, this was the first explosive activity that had occurred at Kilauea since the year 1790, and it has not been repeated since. The activity has been described in detail by Jaggar and Finch (1924) and by Finch (1943).

During the 1924 eruption a large number of angular blocks of lava were expelled from the volcano's orifice and scattered over the floor of the caldera around the great firepit, Halemaumau. For the most part, these blocks vary in size from small fragments up to one rock which weighed 10 tons (Stearns and Clark, 1930, p. 117 and pl. 20c), but R. H. Finch has informed the writer of one exceptionally large block that weighed 13 tons. They were torn from the walls of the vent by the eruption and the majority were undoubtedly crystalline when ejected. The blocks show a variety of textures and mineral assemblages, resulting, apparently, from different conditions of crystallization. Macdonald (1944 b) has already described several of these blocks, some of which differ radically from typical Hawaiian basalts in having peculiar olivine phenocrysts and a hornfels-like groundmass of labradorite, hypersthene, and augite.

In January, 1946, the writer, accompanied by R. H. Finch and Guy C. Omer, Jr., of the Hawaiian Volcano Observatory, visited the floor of Kilauea caldera in the vicinity of the firepit, Halemaumau. They col-

lected several of these blocks, ejected in the 1924 eruption, which show interesting petrographical features. One particular rock type consists of irregular masses of blue-black basaltic glass set in a fine-grained network of plagioclase and ferromagnesian minerals. Due to the fact that basaltic glass has not been previously reported from the ejected blocks of the 1924 explosion, and to the fact that this particular rock type reveals an interesting crystallization history, it was deemed advisable to subject it to special study. The results of this study are presented herewith.

The writer is greatly indebted to R. H. Finch and Gordon A. Macdonald for their critical reading of the manuscript and for their helpful suggestions.

PETROGRAPHIC NATURE OF THE BASALT

The glass-bearing basalt is a heavy, fine-grained, medium-gray rock with what appears at first glance to be a diabasic texture. Close inspection, however, reveals the presence of numerous small radiating intergrowths, averaging 3 millimeters in diameter, made up by the radial arrangement of mineral grains. These radial intergrowths give the rock a variolitic structure which is apparently not uncommon in Hawaiian lavas (Cross, 1915, p. 13; Washington, 1923, p. 344; Stone, 1926, pp. 18-19; Macdonald, 1944 *a*, p. 183). Scattered throughout the crystalline groundmass are irregular patches of blue-black, vesicular basaltic glass, some patches as much as 12 millimeters across. This glass shows a highly vitreous lustre and a faint iridescence, and has good conchoidal fracture. A photograph of the glass-bearing basalt as it appears in hand specimen is shown in Fig. 1.

In thin section the glass-bearing basalt consists of microphenocrysts of olivine and a little pyroxene set in a groundmass of plagioclase, pyroxene, and basaltic glass, with minor accessories. The olivine and pyroxene microphenocrysts are scattered irregularly throughout the rock, but the plagioclase and most of the pyroxene are arranged radially forming little variolitic structures whose diameters average about 3 millimeters. The texture of the basalt is typically intersertal with volcanic glass filling the interstices between mineral grains. These relations are shown in Fig. 2.

The olivine microphenocrysts are nearly square in cross section and about $1\frac{1}{4}$ millimeters on a side, and in some cases show the effects of magmatic resorption. One microphenocryst showed resorption and the later deposition of a narrow rim of pyroxene similar to the pyroxene in the groundmass. Most microphenocrysts show sieve structure with slender laths of plagioclase perforating them quite unconcernedly. Optical study

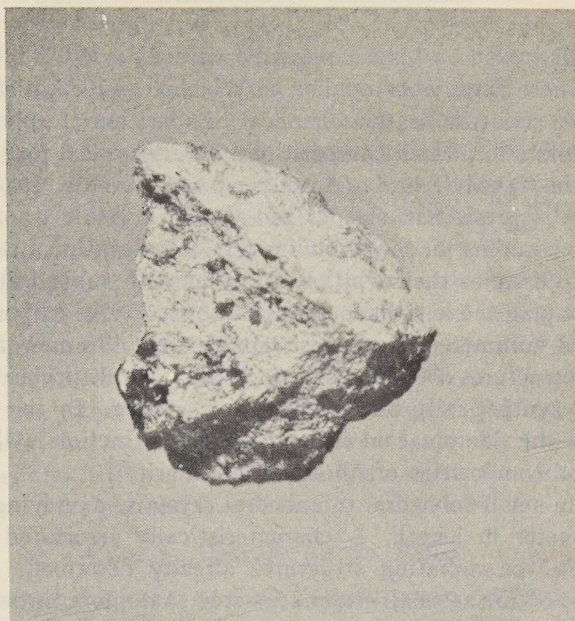


FIG. 1. Block of glass-bearing basalt ejected from Kilauea volcano, Hawaii, during explosive eruption of 1924. Note irregular, black masses of volcanic glass in crystalline groundmass. Specimen is 5 centimeters across.

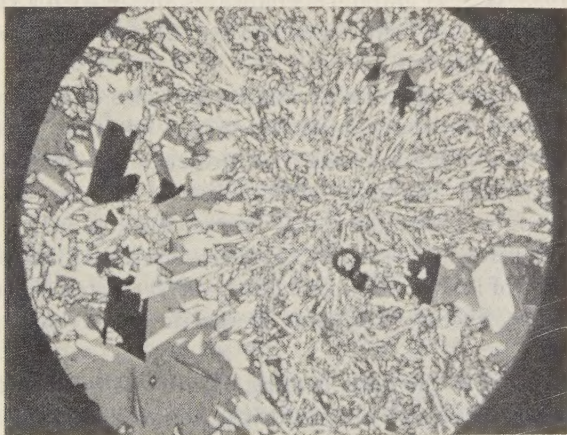


FIG. 2. Photomicrograph, in plane polarized light, of glass-bearing basalt ejected from Kilauea volcano, Hawaii, during explosive eruption of 1924. Note radial intergrowth of labradorite laths (white) and augite crystals (gray). Opaque grains are iron oxide. Uniform gray constituent in southwest portion of slide is interstitial basaltic glass. Note small microphenocryst of olivine between iron oxide grains in western portion of slide. East-west diameter of section is about 5 millimeters.

proves the olivine to be biaxial negative with $2V=85^\circ$, $\beta=1.696$, and $r < v$ weak. These data, when applied to Winchell's (1933, p. 191) graph for the olivine series, indicate a chemical composition of approximately 75 per cent forsterite, which composition is fairly typical for the olivine phenocrysts in Hawaiian lavas (Aurousseau and Merwin, 1928, p. 560).

Plagioclase is present in slender rod-shaped crystals whose lengths range from 0.2 millimeter to 2.0 millimeters. The lengths of the crystals are from 5 to 8 times their widths. Together with subhedral grains of pyroxene, the plagioclase laths form variolitic structures with an average diameter of 3 millimeters, and these compose the "framework" of the rock. These structures are illustrated in Fig. 2. All plagioclase laths are twinned polysynthetically but do not show zoning. In the zone perpendicular to the side pinacoid their maximum extinction is 35° , revealing a chemical composition of $Ab_{37}An_{63}$ (labradorite).

Pyroxene in small subhedral to anhedral crystals, averaging from 0.1 to 0.5 millimeter in length, is characteristically associated with the labradorite in the radiating structures already described. However, pyroxene also occurs as small grains scattered at random throughout the groundmass and also as a few microphenocrysts. The pyroxene associated with labradorite and that in the groundmass shows a faint greenish color but is non-pleochroic. It possesses the following optical properties: Biaxial positive, $2V=52^\circ$, γ =about 1.725, $Z \wedge c=44^\circ$. When applied to Winchell's (1933, p. 227) graph, this indicates augite with a composition of approximately 20 per cent clinoenstatite, 25 per cent diopside, and 55 per cent hedenbergite.

Brown basaltic glass, containing minute particles of iron ore, fills the interstices between the above minerals, and, in addition, occupies large irregular areas in the groundmass. It represents the final step in congelation of the basalt. The index of refraction of the glass is 1.555 indicating a silica content of 53 per cent (George, 1924, p. 365).

Magnetite and ilmenite occur as accessory interstitial masses, molded between crystals of labradorite and augite, and scattered throughout the groundmass. Tiny accessory needles of apatite are inclosed in basaltic glass.

A modal analysis of the glass-bearing basalt was made with a Wentworth integrating stage and the results are shown below:

| <i>Mineral</i> | <i>Percentage</i> |
|------------------------------|-------------------|
| Olivine | 18 |
| Augite | 25 |
| Labradorite | 29 |
| Basaltic glass | 24 |
| Magnetite, ilmenite, apatite | 4 |
| Total | 100 |

The age relations of the constituents of the basalt have been established as follows: Olivine was an early mineral to crystallize since it forms microphenocrysts, some of which were later partially resorbed by the cooling magma. Some labradorite apparently crystallized either contemporaneously with or slightly earlier than the olivine, since it exists as slender laths inclosed within the latter. Some of the augite was later than olivine for in at least one case it borders a resorbed crystal of that mineral. Although a little augite occurs as microphenocrysts and as irregular crystals in the groundmass, most of it is closely associated with labradorite in radiating, variolitic structures. The majority of the labradorite and augite formed contemporaneously. Magnetite and ilmenite were later than either labradorite or augite, since they occur interstitially between the latter. Slender needles of apatite are inclosed in basaltic glass and are thus older. Inasmuch as glass fills the interstices between crystals, it was the latest constituent to form.

COOLING HISTORY OF THE BASALT

The texture of the basalt and the paragenesis of its minerals suggest that the normal basaltic magma, from which it was apparently derived, passed through 3 distinct stages in the process of cooling.

Stage 1. During this stage the magma is thought to have been located at considerable depth below the surface where cooling was slow and undisturbed. Microphenocrysts of olivine and a few of augite formed in the cooling melt, and the absence of zoning in these microphenocrysts suggests that their re-working by the magma was essentially complete. Labradorite crystals were precipitated in this early stage also, and many became encased in the microphenocrysts. In the later part of this stage, some of the microphenocrysts were partially resorbed, and in one case a narrow rim of augite was deposited about a microphenocryst of olivine.

Stage 2. This stage began when the above magma was intruded into the hot walls of the Halemaumau firepit, possibly as the small sill-like body described by Macdonald (1944 *b*, p. 322). Here the cooling of the now rather viscous magma was more rapid than in Stage 1, and labradorite laths and augite crystals formed in radial growths about numerous geometric centers throughout the magma. At the conclusion of this stage the rock consisted of a definite crystal mesh with radial, variolitic structures forming the "framework," and with magnetite, ilmenite, and apatite as accessory minerals.

Stage 3. In this final stage of cooling, portions of the sill-like intrusion were torn violently from the wall of Halemaumau firepit by explosive eruptivity and hurled high into the air. Thus the residual liquid in the pore spaces was chilled to a glass, and the congelation of the basaltic lava was complete.

REFERENCES

- AUROSSEAU, M., AND MERWIN, H. E., Olivine: I. From the Hawaiian Islands; II. Pure forsterite: *Am. Mineral.*, **13**, 559-564 (1928).
- CROSS, W., Lavas of Hawaii and their relations: *U. S. Geol. Surv.*, Prof. Paper **88**, 97 pages (1915).
- FINCH, R. H., Lava surgings in Halemaumau and the explosive eruptions in 1924, *Volc. Letter*, no. **479** (1943).
- GEORGE, W. O., The relation of the physical properties of natural glasses to their chemical composition: *Jour. Geol.*, **32**, 353-372 (1924).
- JAGGAR, T. A., AND FINCH, R. H., The explosive eruption of Kilauea in Hawaii, 1924: *Am. Jour. Sci.*, 5th series, **8**, 353-374 (1924).
- MACDONALD, G. A., The 1840 eruption and crystal differentiation in the Kilauean magma column: *Am. Jour. Sci.*, **242**, 177-189 (1944 a).
- , Unusual features of ejected blocks at Kilauea volcano: *Am. Jour. Sci.*, **242**, 322-326 (1944b).
- STEARNS, H. T., AND CLARK, W. O., Geology and water resources of the Kau District, Hawaii: *U. S. Geol. Surv.*, Water Supply Paper **616**, 194 pages (1930).
- STONE, J. B., The products and structure of Kilauea: *B. P. Bishop Mus.*, Bull. **33**, 59 pages (1926).
- WASHINGTON, H. S., Petrology of the Hawaiian Islands; III Kilauea and general petrology of Hawaii: *Am. Jour. Sci.*, **6**, 338-367 (1923).
- WINCHELL, A. N., *Elements of Optical Mineralogy*, Part II, Descriptions of Minerals, John Wiley and Sons, Inc. (1933).

DIFFERENTIAL THERMAL ANALYSIS OF SOME CARBONATE MINERALS†

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ABSTRACT

Differential thermal analysis curves are presented for ten of the more common carbonate minerals of known purity. The characteristic curves given should aid in detecting the presence of these minerals when they occur in clays or soils being analyzed by this method. The use of differential thermal analysis is suggested for industries utilizing carbonate minerals or their by-products.

INTRODUCTION

Differential thermal analysis, as applied to soils and clays has become increasingly popular within the last few years, and its value for determining the composition of these materials has been proven (1, 2). Consequently, many research and control laboratories have built apparatus designed to yield differential thermal curves. While most of these vary slightly in operation and design they give similar results, and the thermal curves from different laboratories can thus be compared.

In the course of studying and analyzing many clays in the laboratories of the Illinois State Geological Survey it was noticed that frequently samples contained a carbonate mineral which produced a distinct and characteristic thermal reaction (3, 4). The following work was undertaken to characterize the thermal reactions of several of the common carbonate minerals by means of the type of differential thermal apparatus now popular. All of the work was carried out in the laboratories of the Illinois State Geological Survey.

The carbonate minerals analyzed by the differential thermal method and their source are listed in Table 1.

PROCEDURE

The particular differential thermal apparatus used has been described in detail in another paper and is very similar to those in use in other laboratories (3). A heating rate of about 10° C. per minute was used. The carbonate minerals selected for analysis were specimens chosen for their purity. They were prepared for analysis by grinding in a porcelain mortar to minus 60 mesh and carefully picking out impurities under a microscope. Chemical analyses for each of the purified minerals are given in Table 1.

† This work was undertaken while the authors were members of the staff of the Illinois State Geological Survey.

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Because of the fact that the thermal reactions of many of the carbonate minerals are quite vigorous, thermally inert Al_2O_3 was used as a diluent in the proportion of 25% mineral and 75% Al_2O_3 , the two materials being carefully mixed. This allowed all of the minerals to be analyzed without reducing the sensitivity of the differential thermocouple circuit and eliminated the danger of losing a part of the sample because of a vigorous reaction. All of the samples were dried at 90°C . before thermal analysis.

RESULTS

The thermal curves which were obtained using the above procedure are shown in Figs. 1 and 2. All temperatures are noted in degrees centigrade.

Calcite: The differential thermal curve of calcite shows a rather intense broad endothermic reaction starting at about 625° and ending about 890° with a peak at 840° .

Aragonite: This curve also shows a broad endothermic reaction. However, the reaction starts at about 600° , ends at 920° and has its peak at 860° .

Magnesite: The thermal curve for magnesite shows a broad, vigorous endothermic reaction which starts about 400° , ends at 690° and has a peak at 650° . There is also a much smaller endothermic reaction of a much different character immediately following the first.

Dolomite: Two endothermic reactions are shown in the dolomite curve, both of which are sharper than either calcite or magnesite. The first starts about 600° and has a peak at 780° and the second has a peak at 830° and ends about 900° .

Witherite: The thermal curve for witherite shows two small, sharp endothermic reactions; one about 810° , and another about 980° .

Cerussite: Three rather small endothermic reactions are shown in the thermal curve for cerussite. The first starts about 250° and has a peak at 338° , the second immediately follows the first with a peak at 400° , and the third reaction is small and sharp at 855° .

Siderite: Siderite shows a single exothermic reaction starting at about 450° and ending about 625° , reaching a maximum at 560° .

Smithsonite: A single small broad endothermic reaction starting about 300° and ending about 510° , with its peak at 455° is shown in this curve.

Strontianite: A series of relatively small endothermic reactions starting about 800° and continuing past 1000° are shown.

Rhodochrosite: The thermal curve for rhodochrosite shows an endothermic reaction between 500° and 685° with a peak at 625° , and a second rather broad endothermic reaction from 800° to 1000° .

TABLE 1*

| Mineral | Source | % Cation | % CO ₂ |
|---------------|------------------------|--------------------------|-------------------|
| Calcite | Cleavage frag. | CaO— 55.62 | 44.11 |
| Aragonite | Patterson Pass, Calif. | CaO— 56.21 | 43.38 |
| Magnesite | Stevens Co., Wash. | MgO— 45.98 | 50.54 |
| Dolomite | Cleavage frag. | CaO— 31.25 MgO— 20.13 | 46.92 |
| Witherite | Northumberland, Eng. | BaO— 74.98 | 22.40 |
| Cerussite | Embreeville, Tenn. | PbO— 83.33 | 16.41 |
| Siderite | Roxbury, Conn. | FeO— 53.80 | 38.21 |
| Smithsonite | Grant Co., N. Mex. | ZnO— 50.74 | 30.99 |
| Strontianite | Westphalia, Ger. | SrO— 67.80 | 30.89 |
| Rhodochrosite | Butte, Mont. | MnO— 57.20 | 38.46 |

* Analyses by L. D. McVicker, Illinois State Geological Survey.

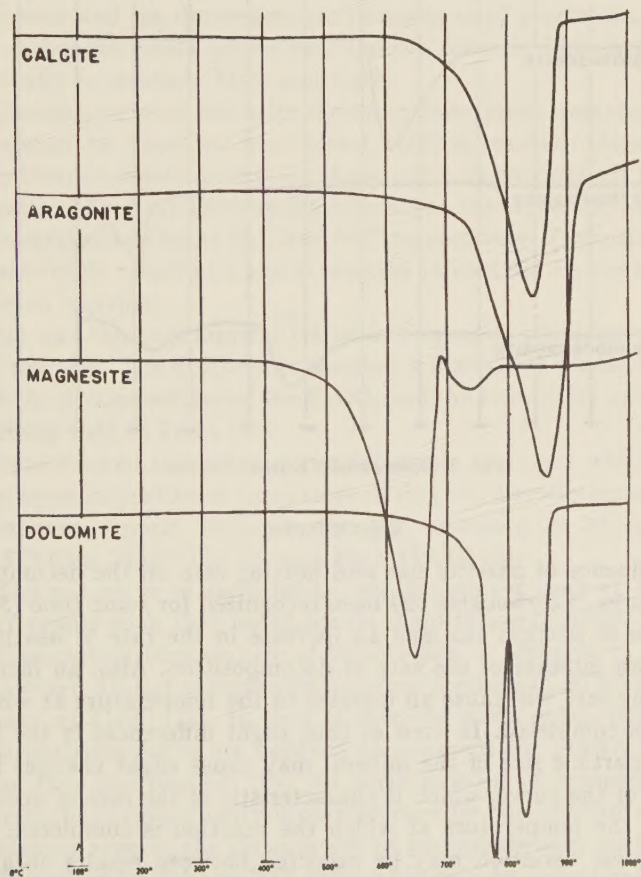


FIG. 1. Differential Thermal Curves.

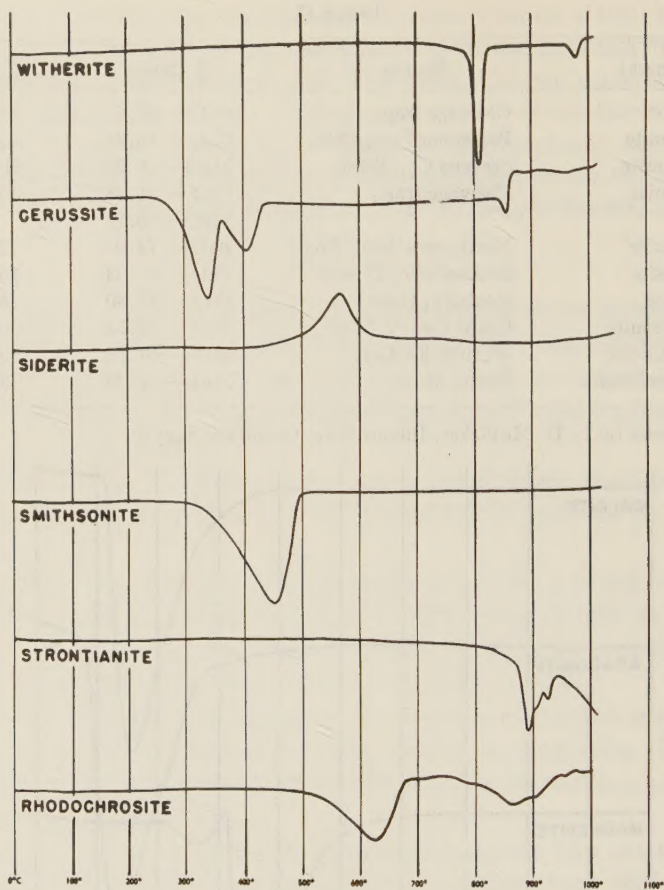


FIG. 2. Differential Thermal Curves.

DISCUSSION

The influence of particle size and heating rate on the decomposition temperatures of carbonates has been recognized for some time (5). Both a decrease in particle size and an increase in the rate of heating, will result in an increase of the rate of decomposition. Also, an increase in the heating rate will cause an increase in the temperature at which the reaction is completed. In view of this, slight differences in the heating rate and particle size of the mineral may cause slight changes in both the slope of the curve, which is characteristic of the rate of decomposition, and the temperature at which the reaction is completed. Consequently some variation may be expected between results obtained in different laboratories.

The differential thermal curves of calcite, aragonite, magnesite, and dolomite can be considered best as a group. Dissociation temperatures for calcite have been recorded in the literature as occurring from about 825° C. to as high as 915°, largely dependent upon the rate of heating (5). Aragonite, when heated above 450° changes more or less spontaneously into calcite and the thermal curves, as obtained, show no significant difference. The dissociation of magnesite occurs at a lower temperature than that of calcite as shown in Figure 1. Wells believes 545° is about right (6). The second endothermic reaction shown in the magnesite curve is probably due to the presence of a small amount of calcite. When double magnesium and calcium carbonates are present, as in dolomite, the thermal curve resulting is not exactly what would be expected by merely combining the curves for magnesite and calcite. A higher temperature is necessary in order to start the decomposition than is required for magnesite and the decomposition proceeds until practically no magnesium carbonate exists before any CaO is formed. This fact is used commercially to separate MgO and CaO.

The thermal curve of witherite shows no dissociation reaction since it does not start to dissociate until about 1100° is reached. However, the two endothermic reactions that do show, serve as an excellent means of identification. They are the transition points to the alpha and beta forms of the mineral occurring at 811° and 982° respectively. Transition points characteristically result in a sharp reaction in contrast to the broad decomposition reactions.

Siderite was the only mineral tested in this series which gave an exothermic reaction. The exothermic reaction is a result of the heat balance between the decomposition of the FeCO_3 and the immediate oxidation of the resulting FeO to Fe_2O_3 (7).

Cerussite showed three distinct endothermic reactions which are believed to be an indication of three steps during the dissociation of PbCO_3 . Tzentnershver reports evidence for the existence of three stages; $3 \text{ PbO} \cdot 5 \text{ PbCO}_3$, $2 \text{ PbO} \cdot \text{PbCO}_3$, and $\text{PbO} \cdot \text{PbCO}_3$ (8).

The thermal curve of smithsonite, which shows a peak at 455° is in good agreement with that noted for its dissociation in other work (9).

The dissociation temperature of strontianite is reported to be 1340° (10). However, Dutoit reports a dissociation pressure of 20 mm. at 952°, of 298 mm. at 1175° (11). In view of this, the series of reactions shown in the strontianite curve are believed to represent the beginning of dissociation. It is also possible that the small amount of impurity present as shown in the chemical analysis may account for part of these reactions.

Krustinsons reports the dissociation of manganese spar as beginning at 407.5° and ending about 700° (12). This may be considered in good

agreement with that obtained in this work for rhodochrosite, in which the reaction started about 500° and was completed about 684° , reaching a maximum at 625° . The second endothermic reaction shown in the rhodochrosite curve may be due to the small amount of impurity present.

SUMMARY

The type of differential thermal analysis apparatus used for studies of clays and soils produces excellent results when applied to the carbonate minerals. Ten of the more common carbonates are analyzed and characteristic curves are given which should aid in identification of the minerals when they occur in clays and soils.

The decomposition temperatures of the carbonates and the inversion temperatures of witherite shown in this study agree very well with those obtained using other methods.

The possibility of using the method for research and control of plant products in various industries is suggested. Industries that produce and utilize limestones and dolomites for example, might well find the method applicable for control, particularly inasmuch as the analysis, as performed in this manner, requires only about two hours for completion, and is capable of detecting small amounts of carbonates which would be easily overlooked otherwise. Another advantage of the method is the relatively small amount of material which is needed for analysis, about 0.3 to 0.5 of a gram.

ACKNOWLEDGMENTS

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REFERENCES

1. GRIM, R. E., AND ROWLAND, R. A., *Am. Mineral.*, **27**, 746-761, 801-818 (1942).
2. SPEIL, S., AND AL., *U. S. Bur. Mines, Tech. Paper* **664**, (1945).
3. GRIM, R. E., AND ROWLAND, R. A., *J. Am. Cer. Soc.*, **27**, 65-76 (1944).
4. CUTHBERT, F. L., *Am. Mineral.*, **29**, 378-388 (1944).
5. WHITING, G. H., AND TURNER, W. E. S., *J. Soc. Glass Tech.*, **14T**, 409-424 (1930).
6. WELLS, R. C., *Trans. Am. Geophys. Union*, 15th Ann. Meeting, Pt. 1, 237-240 (1934).
7. PLOTZKI, E., *Arch. Eisenhüttenw.*, **11**, 263-272 (1937).
8. TZENTNERSHVER, M., *J. Chem. Phys.*, **27**, 9-28 (1930).
9. HUTTIG, G. F., AND AL., *Zeit. Physik. Chem.*, **B19**, 1-21 (1932).
10. HANDBOOK OF CHEM. AND PHYS., 466 (1944).
11. DUTOIT, W., *J. Chem. Phys.*, **24**, 110-114 (1927).
12. KRUSTINSONS, J., *Zeit. Elektrochem.*, **38**, 780-783 (1932).

SODIUM BICARBONATE (NAHCOLITE) FROM COLORADO OIL SHALE¹

TELL ERTL²

ABSTRACT

Sodium bicarbonate (nahcolite) was found in the high-grade oil-shale zone of the Parachute Creek member of the Eocene Green River formation in the underground development openings of the Bureau of Mines Oil-Shale Demonstration Mine at Anvil Points, 10 miles west of Rifle, Colo. It occurs as concretions varying up to five feet in diameter and as layers up to four inches thick, intercalated between rich oil-shale beds. It is suggested that the concretions were formed while the ooze, which had been deposited in the bottom of the former Uinta Lake, was still soft and plastic.

INTRODUCTION

Natural sodium bicarbonate (NaHCO_3) was reported first by P. Walther³ from Little Magadi dry lake, in British East Africa, but no confirmatory evidence was given. F. A. Bannister,⁴ who reported natural sodium bicarbonate in an efflorescence from an old Roman underground conduit from hot springs at Stufe de Nerone, near Naples, gave the mineral the name "nahcolite." Later the mineral was reported by E. Quercigh⁵ as an incrustation in a lava grotto, apparently mixed with thenardite and halite. Large quantities of nahcolite were found in a well core-drilled below the central salt crust of Searles Lake and described by William F. Foshag.⁶

The presence of saline phases in the eastern part of the Uinta Basin in the high-grade oil-shale facies of the Parachute Creek member of the Eocene Green River formation was noted by W. H. Bradley.⁷ He states that ellipsoidal cavities whose major axes range from a fraction of an inch to more than five feet in length contained molds of radial aggregates of a saline mineral that could not be determined because of the complex intergrowth of the crystal molds.

The Bureau of Mines now is developing an underground oil-shale mine at Anvil Points, 10 miles west of Rifle, Colorado. A number of underground openings have penetrated the high-grade oil-shale facies that contain the salt cavities. As the openings were advanced deeper into the

¹ Published by permission of the Director of the Bureau of Mines.

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³ Walther, P., *Am. Mineral.*, **7**, 86-88 (1922).

⁴ Bannister, F. A., *Mineral. Mag.*, **22**, 53-64 (1929).

⁵ Quercigh, E., *Rend. Acad. Sci. (Naples)*, (4) **7**, 19-25 (1937).

⁶ Foshag, W. F., *Am. Mineral.*, **25**, 769-778 (1940).

⁷ Bradley, W. H., Origin and microfossils of the oil shale of the Green River Formation of Colorado and Utah: *U. S. Geol. Survey, Prof. Paper* **168**, 33-37 (1931).

cliffside and away from the outcrop some of the cavities were found to be unleached and to contain a soluble crystalline mineral.

The mineral was found to occur in crystalline, cleavable masses in concretions as large as five feet in diameter and as small as a pea. It also was found in layers up to four inches thick intercalated between oil-shale beds. The mineral in the concretions varies in color from colorless, through white, yellow, brown, and black. Most often the color is a dirty brown because of the bitumen dispersed throughout the mineral. Clear pieces one inch square and one-quarter inch thick have been broken from the concretions.

The mineral occurring in the layers is pure white, translucent, and occurs as fibrous crystals at right angles to the bedding. It has a pearly opalescence and resembles the satin spar variety of gypsum.

IDENTIFICATION

The mineral was taken to the Colorado School of Mines for identification. Professor Richard Merriam of the geology department, Mr. Eugene Staritzky, Associate Director of the Experimental Plant, and the writer determined by optical and crystallographic means that the mineral was nahcolite. cursory spectrographic analyses, made by Mr. Staritzky, showed no important impurities.

Chemical tests on the mineral were made at the Bureau of Mines Petroleum and Oil-Shale Experiment Station, Laramie, Wyoming. Analyses on two specimens show:

| | | |
|--|---------|---------|
| NaHCO ₃ (calculated from total HCO ₃) | 88.29%* | 91.90% |
| Na ₂ CO ₃ (calculated from total CO ₃) | 4.78 | 6.62 |
| H ₂ O insoluble | 6.77 | 0.14 |
| Material unaccounted for | 0.16 | 1.34 |
| Total | 100.00% | 100.00% |
| Acid insoluble | 4.47% | 0.14% |
| CaO (acid soluble) | 1.16% | 0.14% |
| Al ₂ O ₃ and Fe ₂ O ₃ | None | None |

* This sample contained considerable bituminous material.

PARAGENESIS

Nahcolite in the Green River formation occurs in concretions and layers in the high-grade oil-shale bed. Each concretion seems to be composed of just a few large crystal growths since the cleavage is parallel throughout most of the concretion. The oil-shale beds on each side of the concretions are distorted for a short distance above and below, but the beds a few feet above and below the concretion appear in all cases to be flat-lying. (See figure 1.) The highgrade oil shale is an extremely fine-grained,

compact rock. It seems doubtful that solutions could move in the oil shale freely enough after lithification to produce these nahcolite concretions.

Therefore, the writer concludes that at the time of formation of the rich oil-shale beds, the lake was supersaturated with sodium salts. The sodium salts were precipitated as sodium bicarbonate concurrently with the marly mud rich in organic matter that later became oil shale. On

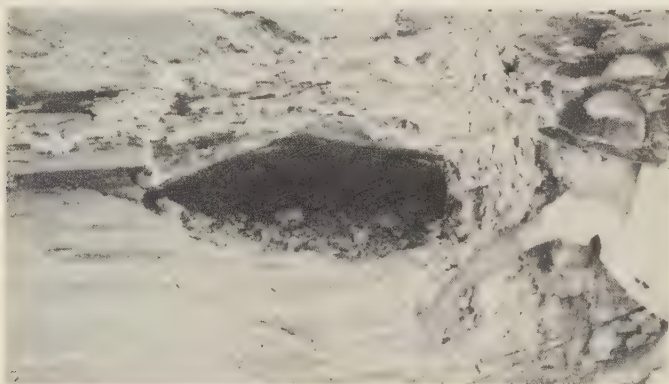


FIG. 1. Leached nahcolite concretions on fresh face of oil-shale cliff, showing distortion of beds immediately above and below the concretion. Note nahcolite efflorescence.

lithification of the deposited material, the sodium bicarbonate began to crystallize along certain planes and as the crystals of nahcolite grew the surrounding oil shale was distorted while still soft and plastic. Nevertheless, as the growing crystals of nahcolite crowded the laminae of oil shale away from them both above and below, the mud was stiff enough to maintain its original laminate structure.

Foshag states that sodium bicarbonate, in open solutions, loses CO_2 and eventually passes to trona ($\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$), therefore it is not often found in nature. He states further that its occurrence in Searles Lake may be caused by an interaction of trona and calcium bicarbonate under conditions that did not allow the escape of carbon dioxide gas. The action of carbon dioxide and water vapor on trona is known to produce sodium bicarbonate. Because the organic-bearing mud that now is oil shale was putrifying on deposition, the lake readily could have had an excess of carbon dioxide that could have caused the deposition of nahcolite rather than trona.

On the other hand it is known that in the system $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot \text{H}_2\text{O}$, trona is not stable below 21.26°C .; NaHCO_3 (nahcolite) and

$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ (natron) are the stable phases. Bradley indicates that the former Uinta Lake must have been 75 to 100 feet deep during long periods of time while the rich oil-shale beds were being deposited. He also believes that the water toward the bottom of the lake was stagnant, and strongly reducing, and distinctly unfavorable for bottom-dwelling animals. In addition he has evidence that the mean annual temperature of the region, and therefore of the stagnant deeper portion of the lake, was of the order of 18°C . The evidence then favors the deposition of the nahcolite directly from a solution rich in sodium salts whose lower layers were stagnant, strongly reducing, and at a constant temperature below 21°C .

SPECTROGRAPHIC ANALYSIS OF TOURMALINES FROM THE ISLAND OF ELBA WITH CORRELATION OF COLOR AND COMPOSITION

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INTRODUCTION

The colors of the beautiful crystals of tourmaline from the Island of Elba and their zonal coloration have always attracted the attention of naturalists. Dolomieu (1) in 1798 examined the tourmalines of Elba described as "half white and half dark"; Ottaviano Targioni Tozzetti (2) (the son of Giovanni Targioni Tozzetti, the great Tuscan naturalist of 1700) described for the first time the tourmalines of different colors that Lieutenant Ammannati collected when he was garrisoned on the Island of Elba.

Antonio D'Archiardi (3), in his "Mineralogia della Toscana," recorded some interesting data on the succession of colors on the crystals and on the variation of density with color; Giovanni D'Achiardi (4) wrote his doctor's thesis on the tourmalines from Elba, after examining about 6000 crystals or fragments of crystals.

More recently, E. Grill (5) found some new forms on the tourmalines from the Island of Elba. From the crystallographic studies of G. D'Archiardi, we note a regular variation of the axial ratio with the color; we have, for example, the lowest value of the axial ratio for the yellow-green tourmalines ($a:c=0.441154$), then follow in order the dark, the colorless, the pale pink, the dark yellow, the greenish yellow, and, lastly, the yellow tourmalines with $a:c=0.454079$. Consequently, the color varies with the chemical composition of the crystals, as is also shown by the specific gravity and by the refractive indices. The black crystals have the maximum density (3.167–3.174), then come the greenish yellow, the pale pink, the colorless (3.017), and the yellow, which are the lightest of all (2.950–3.014).

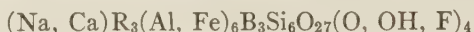
It thus appears that the succession of colors is very similar to that obtained by arranging the crystals according to the increasing value of the ratio $a:c$.

When we consider the double refraction, we can show that the colorless crystals must be classified with the slightly pink and the greenish crystals. We obtain the following succession: pink ($\omega-\epsilon=0.0200$ for yellow light), colorless (0.0204), greenish yellow (0.0220).

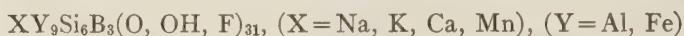
We may conclude that the color, or at least some colors, are influenced by the chromophores which enter in solid solution to a considerable ex-

tent. For some colors (black, green, greenish yellow, and red), the color cannot be attributed to minor constituents present in such small quantities that they could have no influence on the axial ratio and other physical characters.

The structure of the solid solution forming the tourmalines has been determined by M. J. Buerger and W. Parrish (6) on crystals from the Etta Mine, South Dakota, to which they have assigned the space group C_{3v}^5 . Miss Kulazewski (7) and Machatschki (8) had previously reported on the structure of tourmaline. The formula of the solid solution may be written, according to Buerger and Parrish, as:



and in a general way, according to Machatschki:



The elements must be grouped together, as in all minerals, on the basis of ionic radii. Sodium may be replaced by calcium and manganese; 9Y is never represented in nature by 9Al , but instead by Al_8Li or $\text{Al}_5(\text{Mg}, \text{Fe})_4$. The lithium is almost always present, and from the point of view of isomorphism there is equality in the group of the two atoms LiAl with 2 Mg .

For the Elba tourmalines, there was lacking a spectrographic research of the minor constituents, which was necessary for a study of the relationship of composition and color.

SPECTROGRAPHIC ANALYSIS

We have prepared spectrograms of twenty differently colored samples from the black, green and red, to the greenish yellow, all coming from the Museum of this Institute. Every one had been separated from a clear and transparent crystal and carefully examined under the microscope; the very fine powder was crushed in clean mortars, dried in an oven, and then vaporized in the arc of very pure carbon electrodes 0.6 centimeters in diameter of the Ruhstradt firm. The substance (40 mg.) was placed in a cavity .2 cm. in diameter and 1.2 cm. deep, and volatilized in the arc with 190V and 8A for 6'45".

We have used a Zeiss Qu 24 spectrograph; the field of observation was between 5000 and 2300 Å. The focusing adjustment of the slit was for 2800 Å. We used Hartmann's diaphragm T 10 with nine windows and as intermediate screen the D5. The breadth of the slit was 0.006 mm. We used Ferrania Cappelli ultracontrast orthoplates and developed for five minutes with methyl hydroquinone in the developer.

After measuring the wave-lengths corresponding to all lines made on the positive of the spectrogram obtained by enlarging the photographic plates twenty times with the projection comparator, we ascertained for every identified element the presence of the complex or series of lines which characterize it. We have verified this complex not only by various tests, but also by direct experiment on plates especially prepared.

The identified elements (including the normal constituents of the tourmalines) are the following:*

B, Si, Ti, Al, Fe, Ni, Mg, Cu, Mn, Ca, Ba, K, Na, Li, Cs, Be, V, Ta, Sc, Sn, Ce.

In the course of the qualitative analysis, we have also made estimates of the relative abundance of the various constituents in each sample.

In Table 1 we give our results.

We reserve for a later research an exact quantitative spectrographic analysis; in the meantime, we can report the following conclusions drawn from the accompanying table:

Lithium is present in all samples studied, even in the intensely green or black varieties, where it had not been previously identified by the usual chemical methods; the spectrographic analysis has shown that it is present in larger amounts in the pink, yellow, or colorless crystals, while it is present only in minimum amounts in crystals rich in iron.

Copper is always present; it was found in greater quantity in the blue crystals. Iron is present in greater quantity in the green or black tourmalines, as we already know; nickel is present in very small quantities only in the tourmalines very rich in iron. Barium is always present, but in largest quantities in tourmalines rich in iron. The quantity of manganese is greater in the yellow and yellow-green crystals and least in those which are black; this is in accord with results obtained by the usual chemical methods.

Calcium is present in larger quantities in the yellow than in the others; it is absent in the red tourmalines. Beryllium was present in all samples, because it is an isomorphous substituent of silicon. Scandium is present in larger quantities in the green and red tourmalines, and tin is present in larger amounts in the black. Tantalum is present only in the pink, yellow, or colorless crystals, while titanium was found in larger amounts in the crystals containing high iron content.

* We have looked with particular care for the complex of the last lines of the following elements: Rb, Sr, Cr, Zn, Co, Ga, In, P, As, La, Nd, Eu, Nb, Ge, Zr but with negative results.

TABLE I

| Specimen No. | 1 | 2 | 3 | 4 | 5 | 5 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 18a | 18b | 19 | 20 |
|--------------|-------|-------|-------|-------------|------------|---------------|-------------|---------|-------------------|------------|----------|----------|-----------|------------|------|------|---------|---------|------|--------------|------------|------------|
| Color | black | black | black | green black | dark green | yel-low green | light green | yel-low | yellow green pink | light pink | wine red | wine red | light red | light pink | pink | pink | yel-low | yel-low | blue | pink yel-low | color-less | color-less |
| B | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Si | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Ti | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M |
| Al | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Fe | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G |
| Ni | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr |
| Mg | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G | G |
| Cu | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr |
| Mn | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M |
| Ca | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr |
| Ba | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr |
| K | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S |
| Na | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Li | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs |
| Cs | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Be | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr | Tr |
| V | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs |
| Ta | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Sc | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S | S |
| Sn | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs | Vs |
| Ce | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr | Trtr |

Key to chart symbols: X=normal constituent, G=great, M=medium, S=small, Vs=very small, Tr=trace, Trtr=very minute trace.

GEOCHEMICAL CONSIDERATIONS

All the minor constituents determined by spectrographic means may be considered as isomorphous substituents of the major constituents of the tourmalines. Their presence is thoroughly justified by the following geochemical considerations.

It is very well known that lithium, owing to its too small radius (0.78), does not replace the sodium or potassium in minerals, but substitutes for magnesium (0.78). It is found, therefore, in small quantities in diorites, gabbros, and in more basic rocks (9); in the acid rocks it forms its own minerals, such as spodumene or amblygonite, and it partly substitutes for magnesium as in tourmalines ($\text{Al Li} = 2\text{Mg}$).

While rubidium substitutes for potassium and is enriched in the feldspars, particularly in amazonite (up to 2.74%), caesium yields its own minerals in the residuum of the crystallization of the acid rocks, or is present in traces in the potassium minerals, for it has a radius very different from potassium ($\text{K} = 1.33$, $\text{Cs} = 1.65$). Rubidium is present in the micas to a larger extent than is the caesium (muscovite 0.40% Rb_2O ; 0.015% Cs_2O) (10). Therefore, caesium concentrates itself more than the rubidium in the residuum of the crystallization of the granite of the Island of Elba, and we find it in the tourmalines, while rubidium is absent.

Barium found by us in every sample is a replacement of potassium ($\text{Ba} 1.43$, $\text{K} 1.33$); it is known that it is contained in orthoclase (up to 1.5%). The maximum quantity of barium is therefore in the syenites and trachytes (0.18%) (11); the nepheline syenites and the phonolites have only 0.058%, the granites and the liparites 0.048%, the diorites and andesites 0.026%, and the gabbros and the basalts 0.007%. The basic rocks deprived of potassium are also deprived of barium. In the diorites, barium is contained in the biotite (up to 3%); the calcareous rocks have barium only in small quantities.

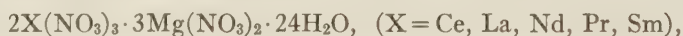
Beryllium, owing to its small radius (0.34), is a minor constituent of acid rocks where it substitutes for silicon (0.39); the quantity of beryllium is greatest in the pegmatites (12), where it forms its own minerals; its isomorphism with magnesium is limited, and so in the basic rocks, it is absent or present in quantities smaller than 0.001%. In the crystals of tourmaline that we have studied, beryllium substitutes for silicon and is always present.

As in the first two groups of the periodic system, a geochemical analogy does not exist between sodium and potassium, and between magnesium and calcium, so there is no analogy in the third groups between aluminum and scandium. Scandium is a substitute for magnesium, and it is hidden in the iron and magnesium minerals (13); all the magmatic

olivines contain scandium, as do augite, diallage, and other pyroxenes and amphiboles (Mg 0.78 Å, Sc 0.89, Zr 0.87).^{*} Therefore, in the tourmalines, the quantity of scandium present is larger in the green iron and magnesium-rich crystals. Titanium is present in all analyzed samples, and it is a substitute for iron and silicon. The geochemistry of niobium and tantalum is not very well known, but tantalum should have a behaviour like phosphorus and in the tourmalines substitute for silicon. Copper is present in the tourmalines as an isomorphous substitute for magnesium.

In the first group of the periodic system, Cu, Ag, and Au are clearly chalcophil; likewise in the second group, Zn, Cd, and Hg; and in the third, Ga, In, Tl; but the first element of the three series is often hidden in the minerals of the rocks. Copper in very minute traces is very common as a substitute for the isomorphous group Mg-Fe" in the silicates of the rocks. This substitution has not been studied sufficiently, and cases of isomorphous substitution of magnesium by copper in simple compounds are not known in chemistry.

Many years ago, one of us (14) demonstrated that in the very well known double nitrate of the series:



magnesium can be partially or entirely replaced by copper and also by cadmium.

MINOR CONSTITUENTS AND COLOR

In the solid solution which constitutes the crystals of tourmaline that we have studied, the presence of the minor constituents that we have found is explained by their isomorphism with some major constituents; there remains to be determined the relationship between minor constituents and color.

The question of the color of allochromatic minerals is one of the partially solved mineralogical problems. Formerly, we always attributed the color to the presence in the crystals of elements which usually gave colored compounds; only recently have we noticed in colored allochromatic minerals the absence of colored compounds, and the color was then attributed to a physical phenomenon, as ionic deformation in the crystal.

Kraatz, Koschlov, and Wöhler (15) thought color was due to inorganic pigments. Weinschenk (16) found titanium in the smoky quartz, and he prepared some colored corundum with inorganic pigments.

^{*} Newhouse has also reported that magnetite of granitic pegmatites contains scandium and not the others. (*Carnegie Inst. Wash. Publications*, Year Book, No. 40 for the year 1940-41, pages 142 to 144. Issued December 12, 1941.)

Brauns (17) was the first to use the absorption spectrum for the identification of the chromophores. Then followed Weigel and Habich (18), and especially Kolbe (19), who compared the absorption curve of a number of chemical compounds in pure crystals and in solutions with those of various allochromatic minerals.

In particular, he studied the absorption of the compounds of Mn, Cr, Fe, and Ti. From such comparisons, it appears probable that titanium would produce part of the color of amethyst; ferrous iron, of the green tourmalines, of clinocllore and of xanthophyllite; ferrous and ferric iron, of blue sapphire, spinel, and of green corundum; chromium, of the red and green spinel, of alexandrite, blue disthene and of the emerald; trivalent manganese, of the pink tourmalines and of red almandine. The absorption curve of the pink tourmalines presents also a certain affinity with that of potassium permanganate.

But the question of the color of allochromatic minerals is certainly not concluded with the investigations by means of the absorption curve of the constituent which has produced the color. In many cases, the color is determined by substances which isolated are colorless or have a different color from that which they bestow on the mineral in which they are found.

K. Chudoba (20) has shown that green zircons have a specific weight less than ZrSiO_4 and reveal some differences in the structure; they contain amorphous SiO_2 and ZrO_2 . On heating to 1450° , the specific weight increases, and the color changes from blue to yellow.

Perhaps the presence of amorphous material might be due to radioactive substances. Machawsky (21) has drawn attention to other variations of color due to the heating; morion becomes yellow at 500° ; amethyst becomes colorless at $300\text{--}400^\circ$, then opalescent and then yellow at $575\text{--}750^\circ$; some amethysts from Paraguay become yellow at $390\text{--}450^\circ$, but return to the amethyst color upon exposure to radium. Analogously, as Chudoba has pointed out, green beryl becomes blue if it is heated at 400° ; yellow or brown topaz becomes pink upon heating, and with ultra-violet rays changes to yellow again.

These changes of color are in part due to chemical reactions, and specifically to a change resulting from the oxidation of the chromophore. The change of color of green tourmalines and of beryl when heated would be due to the oxidation of iron, that of topaz to the oxidation of vanadium. However, in many cases, it is not a chemical but a physical phenomenon; it is a question of the deforming influence of ions on the orbits of other ions which are easily deformed, as for example in PbI_2 , which is yellow on account of the deforming influence of Pb'' , while NaI is colorless because Na' is only slightly deformed.

In fact, it is not possible to explain as a chemical phenomenon the pink color of beryl as due to the presence of caesium [Klemm and Wild (22)] or the green color of the microcline as due to the presence of rubidium and caesium (Goldschmidt) (23). Likewise, according to its dispersion, the same pigment can give different colors to fluorite (Chudoba, Kleber, and Siebel) (24); so, at times, the color does not depend on the chemical nature of the chromophore.

In the particular case of tourmaline, Scharizer (25) in 1889 stated for the crystals from Schuttenhofen that the deep green color was due to iron and that the crystals became pink when manganese is present; that is, when the ratio MnO/FeO increases. When the content of iron equals manganese, the color deepens with the increase of the content of titanium. The deep green or black tourmalines are associated (in Schuttenhofen) with rutile and ilmenite, while the blue tourmalines often contain tin and are associated with cassiterite.

Scharizer (25) stated that lithium would be absent in the deeply colored tourmalines. Rammelsberg (26) and Sommerland (27) drew attention to the fact that red and pink tourmalines from Scheitauks contain manganese but no iron. Riggs (28) found that the red and pink lithium tourmalines contain manganese. Kuntz (29) believes that the red and pink colors depend on trivalent manganese and that scandium and cerium also contribute to the coloring.

MacCarthy (30) attributes yellow and green colors to iron in various stages of oxidation. It seems that we should pay but slight attention to the ideas of Vernadsky (31) on the presence in the tourmaline of a kaolinic nucleus that, added to other groups, would give colors, as is the case in sodalite, haüynite, and cancrinite. The presence of this nucleus does not appear to be in accord with the composition of tourmaline.

In the opinion of Wild (32), the chromophores in tourmaline are Fe, Mg, Mn, and Co (magnesium would not cause color, but would have some influence on the others). Secondary agencies of color would be Ga and Sn; casual chromophores include Ni, Pb, Bi, and Sn. Wild assigns the responsibility of every color to a combination of elements. In the opinion of Holden (33), the color of rubellite is due to trivalent manganese (while the divalent and the tetravalent manganese would not affect the color), and colorization by heating would be a process involving reduction.

Recently, T. W. Warner (34) made a spectrographic analysis of the tourmalines from San Diego,* and he has found the following elements present in every sample: Li, Na, Mg, Ca, Al, B, Mn, Si, V; and in some of

* One sample is indicated as coming from Brazil.

them K, Cu, Fe, Pb, Sn, Ti, and Be. In the opinion of Warner, Li, Na, Mg, Ca, Al, and B have no influence on color; copper is more frequent in the green tourmalines than in those which are pink; instead, tin is more marked in the pink.

Concluding our researches from the point of view of color, we may affirm that:

The green color, as previously noted, is due to the presence of divalent iron.

The pink color is due to the presence of manganese with lithium and caesium.

The blue color is caused by the presence of copper, and particularly if strengthened by the strongly deforming action of Cu^{++} in the same way as in the copper ammonium complex, where the deep blue color is due, according to Fajans, to the deforming action of Cu^{++} on the electronic orbits of the molecule of ammonium.

REFERENCES

- (1) BRONGNIART, *Traité de Minéralogie*, **1**, 406, Paris (1807).
- (2) TOZZETTI, O. T., Minerali particolari dell'isola dell'Elba ritrovati e raccolti dal Sig. Giovanni Ammannati, Florence (1825).
- (3) D'ACHIARDI, A., *Mineralogia della Toscana*, Pisa, **2**, 194 (1872).
- (4) D'ACHIARDI, G., Le tormaline del granito elbano: *Atti della soc. Toscana di Scienze Naturali*, Pisa, *Memorie*, **12** (1893), and **15** (1896).
- (5) GRILL, E., Nuove forme cristalline della tormalina elbana: *Atti della soc. Toscana di Scienze Naturali*, Pisa, *Memorie*, **34**, 243 (1922).
- (6) BUERGER, M. J., AND PARRISH, W., The unit cell and space group of tourmaline: *Am. Mineral.*, **22**, 1139 (1937).
- (7) KULASZEWSKI, CHARLOTTE, Über die Kristallstruktur des Turmalins: *Abhandl. math. phys. Klasse. sächs. Akad. Wissen.*, **38** (1921).
- (8) MACHATSCHKI, F., Die Formeleinheit der Turmalins: *Zeits. Krist.*, **70**, 224 (1929).
- (9) STROCK, L. W., Zur Geochemie des Lithiums: *Nachr. Ges. Wiss. Göttingen, Math.-Physik. Klasse, Fachgruppe IV*, **1**, No. 15 (1935).
- (10) GOLDSCHMIDT, V. M., BERMAN, H., HAUPTMANN, H., UND PETERS, CL., Zur Geochemie der Alkalimetalle I: *Nachr. Ges. Wiss. Göttingen, Math.-Physik. Klasse. Fachgruppe III*, No. 34, *IV*, No. 35 (1933).
GOLDSCHMIDT, V. M., BAUER, H., WITTE, H., Zur Geochemie der Alkalimetalle II., *Ibid.*, *Fachgruppe IV*, **1**, No. 4 (1934).
- (11) VON ENGELHARDT, W., Die Geochemie des Barium: *Chemie der Erde*, **10**, 187 (1936).
- (12) GOLDSCHMIDT, V. M., UND PETERS, CL., Zur Geochemie des Berylliums: *Nachr. Ges. Wiss. Göttingen, Fachgruppe III*, No. 23; *IV*, No. 25 (1932).
- (13) GOLDSCHMIDT, V. M., UND PETERS, CL., Zur Geochemie des Scandiums: *Nachr. Ges. Wiss. Göttingen, Fachgruppe III*, No. 14; *Fachgruppe IV*, No. 16 (1931).
- (14) CAROBBI, G., *Rend. R. Accad. Naz. Lincei*, Series 5, **33**, pp. 246 and 322 (1924).
- (15) *Min. Petrog. Mitt.*, **18**, 304 (1899).
- (16) *Zeit. inorg. Chemie*, **12**, 375 (1896); *Min. Petrog. Mitt.*, **19**, 144 (1900).
- (17) *Fortsch. Min.*, 129 (1911).
- (18) *N. Jahrb. Min., B.B.*, **57**, 1 (1928).

- (19) *N. Jahrb. Min., B.B.* **69**, 183 (1935).
- (20) *Deutschen Goldschmiede Zeitung*, No. **43** (1937).
- (21) *Deutschen Goldschmiede Zeitung*, No. **23** (1939).
- (22) *Centr. Mineral.*, 295 (1925).
- (23) *Nachr. Ges. Wiss. Göttingen*, **I**, 48 (1934).
- (24) *Chemie der Erde*, **13**, 472 (1941).
- (25) *Zeits. Krist.*, **15**, 337 (1889).
- (26) *Mineral Chem.*, **2**, 540 (1872).
- (27) *Zeits. Kryst.*, **11**, 440 (1886).
- (28) *Am. Jour. Sci.* (3), 35 (1888).
- (29) *Chemie der Erde*, **4**, 226 (1940).
- (30) *Am. Mineral.*, **11**, 321 (1926).
- (31) *Zeits. Kryst.*, **53**, 387 (1932).
- (32) *Centr. Min.*, 327 (1931).
- (33) *Am. Mineral.*, **9**, 101 (1924).
- (34) *Am. Mineral.*, **20**, 531 (1935).

ON THE SYNTHESIS OF NEPHELINE*

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Since the procurement of oscillator quartz became progressively worse during the war, and since the synthetic production of quartz did not seem to be proceeding sufficiently well, Professor Carl F. Correns pointed out the possibility that nepheline, which is known to possess piezo-electric properties but occurs in too small size in nature, might be obtained in sufficient purity and size from a melt. In addition, it seemed desirable to attempt to replace sodium by other ions in order to improve the piezo-electric qualities.

Fouqué, Michel-Lévy, Doelter, Bowen, Eitel, and recently, Tilley, have synthesized nepheline, NaAlSiO_4 . However, in each case the crystals were of microscopic size. Furthermore, in the synthesis of nepheline—as in Bowen's experiments—carnegieite, the high temperature modification, rather than nepheline is first crystallized from the melt; nepheline is stable only below 1248°C .

Lowering the temperature at which the crystallization of a phase begins can be brought about by the addition of a new component to a system. In addition, it has been known for almost a hundred years that in the synthetic formation of minerals the possibility of crystallization from the melt is enhanced greatly by the addition of suitable materials. These materials are called "agents mineralisateurs," "mineralizers," or, in certain cases, "crystallizers." At first only gases which do not combine with any of the other substances were considered; gases, which merely through their presence, dispose these latter to crystallization. Subsequently the term mineralizer was expanded to include other materials, such as, for example, tungstic acid, boric acid, and the like.

It was proposed to synthesize nepheline by finding a suitable mineralizer, which, when added to a melt, would form a system with the components Na_2O , Al_2O_3 and SiO_2 in which nepheline would appear as the primary phase at temperatures below 1248°C . New experiments had to be undertaken since extremely little is known of the course of the reactions in the presence of any one of the mineralizers, and because the views about them are so much at variance. In these experiments the first object was to secure the clearest and largest nepheline crystals possible, and the second was to obtain some answers to the admittedly very involved complex of questions about the so-called mineralizing effect.

* English translation by Professor A. C. Swinnerton, Antioch College, Yellow Springs, Ohio, and Mr. Howard M. Schott.

CRYSTALLIZATION WITH THE ADDITION OF MINERALIZERS

Experimentation started with a mixture of sodium carbonate, aluminum oxide and anhydrous silicon dioxide in the stoichiometric proportions of nepheline, $\text{Na}_2\text{O}:\text{Al}_2\text{O}_3:\text{SiO}_2 = 1:1:2$. To this mixture were added quantities of the following substances, known to be mineralizers: sodium tungstate, sodium metaborate, vanadium oxide (V_2O_5), ferrous oxide, to the extent of 15–20% by weight. Since this type of mixture was not completely melted at 1200°C ., a further addition of LiF, in the proportion of 10% by weight, was made in order to secure a further lowering of the melting point. In this way nepheline crystals were obtained, in some cases at temperatures under 1200°C ., and in the case of the metaborate plus LiF, crystals which reached the considerable size of 4×2 mm. But these crystals always grew as "skeletons" with many glassy inclusions; hence still other mineralizers had to be found. It developed that with the addition of fluorides only, nephelines were formed with the fewest glassy inclusions. Therefore, the nepheline-LiF system was investigated more carefully. The diagram of Fig. 1 was obtained which shows not a binary system, but rather a section through a complicated polycomponent system.

Particularly worthy of note is the steep drop in the melting point curve on the nepheline side as the quantity of LiF increases. In the growing of crystals, especially from a melt of the alkali-halogen type, the lowest possible melting point is to be desired for purely practical and material reasons, and especially since the vapor pressure of LiF is quite small at temperatures of less than 1100°C .

From the diagram it is seen that crystallization of nepheline continues up to the eutectic at 86 mol % LiF (53% by weight). The eutectic is at 908° . The synthetic nepheline has the same structure and the same planar spacings as the natural mineral. Optically its refractive indices $\omega = 1.532$ and $\epsilon = 1.528$ lie within the values that Bannister gives for natural nepheline, $\omega = 1.5299 - 1.5403$ and $\epsilon = 1.5266 - 1.5371$. Double refraction, too, is as low as in natural crystals.

With more than 86 mol % LiF a new alkali-aluminum silicate is formed in hexagonal crystals up to 3.5×4.5 mm. This was recognized unmistakably as LiAlSiO_4 , that is, as Li-nepheline. The crystals contained a certain limited amount of LiF but sodium could no longer be detected. The sodium has separated out from the silicate melt and has gone over to the lighter fluoride fraction as NaF. This liquid mixture is indicated in the diagram.

The hexagonal crystals, which show only the faces of a pyramid, and,

more rarely, those of a prism, vary optically from nepheline only in their somewhat lower refractive index: $\omega=1.524$ and $\epsilon=1.520$. Li-nepheline is found in nature as an alteration product of spodumene and is known by the name of eucryptite. It occurs only intergrown with albite, without forming independent single crystals. Earlier syntheses have made no crystals suitable for the determination of crystalline structure; hence,

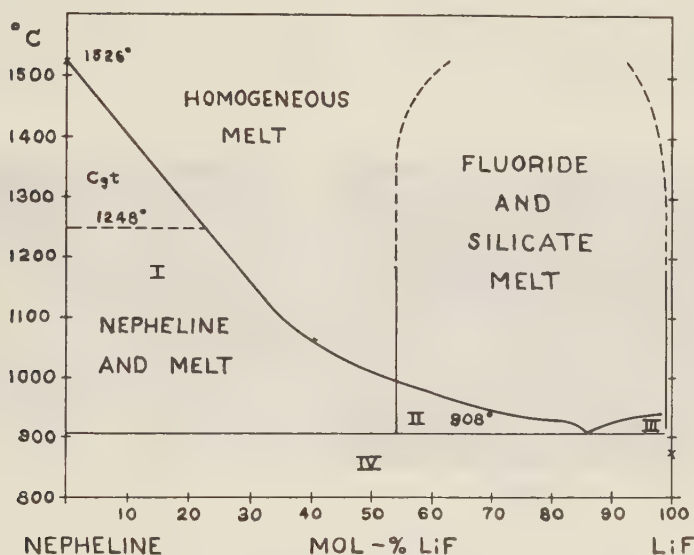


FIG. 1. Melt Diagram of Nepheline-LiF.

II. Nepheline+Silicate-Fluoride melt.

III. Li-Nepheline+Silicate-Fluoride melt.

IV. Nepheline+Li-Nepheline+LiF+NaF.

Cgt. = Carnegieite.

NOTE: The melting points shown must be understood to include the fact that CO_2 is present in the system, since Na_2CO_3 was used initially to obtain the component Na_2O . Although CO_2 escapes to a considerable degree during the melting, a certain quantity does remain dissolved in the silicate melt and involves a limited lowering of the crystallization temperature of the silicate phase; it may be estimated from other experiments that the lowering of the temperature due to this cause amounts to about 20°C .

the structure of eucryptite is still entirely unknown. It is not, however, an unimportant point, especially as concerns piezo-electric crystals. For if eucryptite has a polar axis as does nepheline, then it may display the property of piezo-electricity and possibly even in greater degree than nepheline. Therefore, the structural analysis should be carried out.

DEPENDENCE OF THE CRYSTAL SIZE ON THE AMOUNT OF LiF IN THE SYSTEM

Upon addition of LiF to the components of the nepheline system, nepheline crystallizes out without difficulty in the form of hexagonal plates with a base and a short prism. So far as the size of the crystals is concerned, with 15° to 30° undercooling and with the addition of 5.5% by weight of LiF in the system, the crystals achieve a maximum diameter of only 0.8 mm., but with 19% by weight they reach a size of 2–3 mm.; in other words, increasing the LiF content causes the size of the crystals to increase. (See Figs. 2 and 3.)



FIG. 2

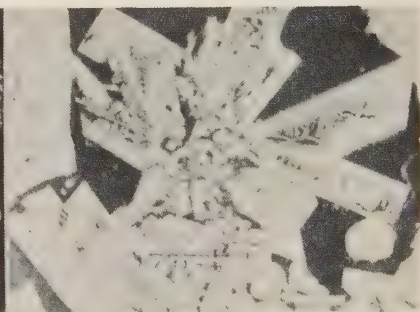


FIG. 3

However, with a LiF content higher than 19%, further increase in crystal size does not take place, although the conditions of the experiment had been so arranged that the growth to a still larger size was not limited by considerations of space or material.

The nepheline which crystallized in the nepheline-LiF system reached the size of a few millimeters, as described above; but the crystals are physically defective, since they crystallized not as skeletons, as was the case in the experiments with the other mineralizers, but rather they contained a considerable quantity of inclusions. Experiments to obtain more homogeneous crystals by slow cooling (one degree C. per hour) were unsuccessful.

SODIUM SILICOFLOURIDES PLUS LiF AS MINERALIZERS

Recently silicofluorides have been used as mineralizers. Therefore experiments were undertaken in which, to the components of the nepheline system taken as equal to 100% by weight, 10% by weight of LiF and varying quantities of sodium silicofluoride were added. Crystals were obtained which were about 3 mm. in size and which contained somewhat

fewer inclusions. By varying the quantities of Na_2CO_3 , Al_2O_3 , and SiO_2 , considerably better results were obtained. When this variation is carried out systematically, a picture is obtained of the extent to which the clarity, the formation of the faces (blockiness, holes, or flawless flat surfaces) and even the crystal size are dependent on the composition of a system, even when the changes in the composition occur within the relatively narrow margin of about 6%. As a result of many experiments in which the addition of 10% by weight of LiF remained constant, the best combinations with Na_2CO_3 , Al_2O_3 and SiO_2 were found, yielding the clearest nepheline crystals up to this time, when 10, 16, or 22.5% of sodium silicofluoride were successively introduced. These crystals had well formed faces (uniform reflection), and reached an optimum diameter and thickness. Crystals were obtained with a diameter of 5, 6, and even 7 mm. with a thickness of 1–2 millimeters. Small crystals of about 1 mm. were completely clear while larger ones had a slight veil of foreign inclusions.

It may now be demonstrated that sodium silicofluoride has no unique effect which furthers crystallization. It is rather the NaF which is formed by simple reaction with the components present in the system that performs this function together with the LiF already present. It can also be shown that neither the SiO_2 nor SiF_4 , which are set free by the reaction with the silicofluoride, has an effect on the formation of the crystals.

From this special example of the synthesis of nepheline, one recognizes what conditions are necessary to obtain large clear crystals as free as possible from foreign inclusions. From the knowledge of the quantities of the various elements present in the system, and from the knowledge of all the phases occurring, one can picture the reaction complex presented in this system. Thus one reaches the surprising conclusion that the best crystals are formed from combinations which are almost identical in their chemical composition with only a variance of a few per cent in the amounts of fluorine (and CO_2), although one actually started with three very diverse mixtures. The phases which accompany the formation of nepheline are always the same, and their mutual mass relationships seem to vary only slightly at most. Cryolithionite, $\text{Na}_3\text{Al}_2(\text{LiF}_4)_3$, and lithium fluoride (with some CO_2) were identified as phases accompanying nepheline. In addition, a small amount of a crystallized phase appeared which it was not possible to identify. Cryolithionite, LiF, and the unknown phase form a massive aggregate of tiny crystals which can only be determined by x-rays; the aggregate of tiny crystals is present in re-entrants in the nepheline crystals and on the upper surfaces of the crystallized charges. Taken as a whole, one can estimate the mass of the phases which are formed in an optimum system by weight thus:

| | |
|-----------------------|--|
| 80% nepheline | } (Calculated as a CO ₂ free system, equal to 100%.) |
| 10-12% cryolithionite | |
| 5% lithium fluoride | |
| 3-5% unknown phase | |

Thus it must be these accompanying phases which permit both the ready crystallization of the components into nepheline, as well as the possibility of growing large crystals. Obviously, the clarity of the crystals depends, for one thing, on the quantities of the components in the system having been so chosen that they agree with the stoichiometric proportions of the phases to be formed. If an excess is present, in general it will not be capable of crystallization and will be inclosed as glass by the growing crystal.

Why exactly these particular accompanying phases work so well in the synthesis of nepheline is a question which cannot as yet be answered.

It can be shown from the special case which has been cited that there are syntheses in which one cannot speak of a vague "mineralizing effect" of certain substances which have been added, even when these are fluorides and silicofluorides, for these substances form new phases within the framework of normal chemical reactions, constituting a complex system difficult to control and direct, but in which the desired crystals can grow flawless and relatively large. The accompanying phases which bring about the best conditions for crystallization can be only empirically ascertained, until the underlying causes have been recognized.

AN ANOMALOUS THERMAL EFFECT IN QUARTZ OSCILLATOR-PLATES

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ABSTRACT

The oscillation frequency of a quartz oscillator-plate shifts abruptly when the plate is suddenly exposed to infrared radiation. The shift is downward for *BT* cut plates and upward for *AT* plates. That the effect is distinct from normal temperature drift is shown by the fact that it can be made opposite to the normal drift by proper orientation and dimensioning of the plate. The magnitude of the effect is about one part in one hundred thousand, for radiation intensities employed. Since the shift occurs only when the surface of the plate is differentially exposed, it is tentatively concluded that the cause is related to thermal strain.

The discovery by Frondel¹ that the oscillation frequency of a quartz oscillator-plate could be substantially altered by prolonged exposure of the plate to x -radiation prompted the investigation of the effects of other wave lengths of radiation. It is the purpose of this note to describe a new thermal effect produced by radiant energy in the infrared region. Although the effect is of little or no practical use, its anomalous character is of sufficient scientific interest to warrant its discussion.

If a conventional quartz oscillator-plate, such as is used in the *CR 5* unit, mounted in a holder which has been provided with a hole approximately one-quarter of an inch in diameter through both the plastic case and metal electrode, is suddenly exposed to infrared radiation while oscillating in a Pierce type circuit, an abrupt change in the fundamental oscillation frequency is observed. The source of radiation may conveniently be a soldering iron operated below red heat, circa 500° C. For a plate having a fundamental frequency of about eight megacycles and with the source of radiant energy about three inches from the crystal, the change observed is of the order of eighty cycles per second, or approximately one part in one hundred thousand. The jump in frequency is unrelated to the normal frequency drift encountered as the temperature of the unit increases and, indeed, may be made opposite to it in direction by proper orientation of the oscillator plate. When the radiation is cut-off, the frequency again shifts abruptly, this time in the opposite direction.

That the effect is distinct from normal heating effects is amply demonstrated by the fact that the direction of shift is downward for *BT* cut plates, regardless of the direction of temperature drift. Thus, a plate so

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¹ Frondel, C., *Am. Mineral.*, **30**, 432 (1945).

cut that its turning point is above room temperature and whose frequency, therefore, increases slowly as the unit is warmed, shows a drop in frequency on sudden exposure to infrared radiation. *AT* cut plates, on the other hand, show an upward jump, again regardless of the normal direction of drift, which may be negative in properly oriented and dimensioned plates. (The different direction of shift in the two cuts eliminates capacitance changes as a cause.)

Since there appeared to be little chance of practical application of the phenomenon, no thorough investigation of it was made. Certain preliminary experiments were conducted, however, and the results of these will be described briefly.

Rapidity of the Effect: If the oscillating crystal is brought to zero-beat with a standard oscillator and the Lissajous ring viewed on an oscilloscope screen, the frequency shift can be seen as the stationary ring begins immediately to precess. For shifts of the order of one hundred cycles per second, the change appears to occur instantaneously. For smaller shifts, in which the precession of the ring is slower, some evidence of a finite length of time for the effect to build up can be observed. The length of time required must, however, be about the same as that for the eye to adjust itself to the new pattern. If the shift is followed audibly by the change in the beat note, the same results are obtained. With a rapid alternation of the infrared source off and on, a fluctuating beat note can be heard. Exposure of a *BT* cut plate having a positive temperature coefficient results in an immediate change in the beat note followed by a gradual return to zero beat and beyond. The first change is the anomalous effect and the return is the normal frequency drift as the crystal warms.

Magnitude of the Effect: As indicated previously, the infrared frequency shift is about one part in one hundred thousand of the fundamental frequency for the radiation intensities employed. This applies particularly to *BT* cut plates. For *AT* plates, the shift is somewhat less. The magnitude is a function—probably exponential—of the fundamental frequency. This is shown by the following observations, Table 1, on an

TABLE 1. ANOMALOUS SHIFT AS A FUNCTION OF FUNDAMENTAL
FREQUENCY OF AN *AT* PLATE

| Fundamental Frequency | Thickness of Plate | Anomalous Shift |
|--------------------------|-----------------------|--------------------|
| 2028.85 kc./sec. | .033 in. | +10 c./sec. |
| 3073.00 | .022 | +30 |
| 4031.90 | .016 | +65 |

AT cut plate which was progressively reduced in thickness. The data in Table 1 were obtained using an infrared source, about 300°C ., at about one and one-half inches from the oscillator-plate. They are not sufficiently accurate for purposes other than illustration. No effort was made, for instance, to take into account the possible influence of lateral dimensions of the plate on the magnitude of the shift. Actually, the plates were not "dimensioned." Such a study might be informative.

As would be expected, the magnitude of the effect varies inversely as the square of the distance from the source of radiation to the crystal. Exposure of both sides of the crystal simultaneously appears to double the amount of shift.

Persistence of the Effect: Experiments conducted over periods of time up to two hours indicate that the effect is a continuing one. In one typical experiment, a plate was exposed continuously for two hours. At fifteen minute intervals, the radiation was momentarily cut off and the frequency shift noted. Although the fundamental frequency of the plate

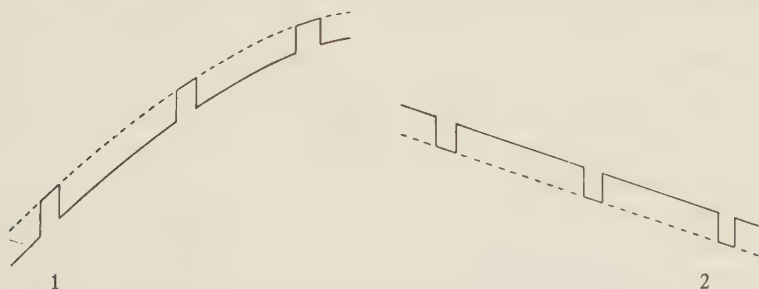


FIG. 1. The frequency of a *BT* plate as a function of time during exposure to infrared radiation, with periodic cut-off of radiation. Dotted line is the normal frequency; solid line the actual frequency. Cut-off results in abrupt shift back to the normal frequency (schematic).

FIG. 2. The frequency of an *AT* plate as a function of time during exposure to infrared radiation, with periodic cut-off of radiation. Dotted line is the normal frequency; solid line the actual frequency. Cut-off results in abrupt shift back to the normal frequency (schematic).

changed a great deal during the test, the magnitude of the anomalous shift did not change appreciably. Actually, it appeared to increase slightly, but this observation has not been confirmed. Under the conditions described above of continuous exposure, the crystal is oscillating at a frequency different from its normal frequency and cut off of the radiation causes a reversion to the normal. In the case of *BT* cut plates, oscillation during exposure is below the normal and cut off causes an upward shift. For *AT* cut plates, the opposite is true. This is shown schematically in

Figs. 1 and 2, where the solid lines are the actual oscillation frequency and the dotted lines the normal frequency.

Influence of the Nature of the Surface: An oscillator-plate was etched sufficiently to be transparent and one side was roughened with aluminum oxide. Measurements were made of the anomalous shift with the rough surface and with the smooth surface exposed. The results were inconclusive, but exposure of the smooth surface appeared to give a higher shift.

Plated Crystals: A silver plated *BT* cut crystal was removed from its holder and exposed to infrared radiation while oscillating. When the entire surface was exposed, no anomalous shift was noted. A small area at the center of the plate was cleaned of silver by nitric acid etching. A small anomalous effect was observed. Bertsch,² while verifying the existence of the effect, observed an anomalous frequency shift using gold plated *BT* cut plates mounted in a plastic holder with a one-quarter inch entry port. The plating was not removed from the surface.

Effect of Cold Air: One of the more interesting aspects of the phenomenon is the effect of cold air. If the source of radiation is replaced by a cold air blast directed at the exposed surface of the plate, a frequency shift opposite to that produced by infrared is observed. The abrupt shift is upward for *BT* cut plates and downward for *AT*. The reversion to the normal frequency appears to be somewhat slower, however, than when infrared is used. There was some indication that the magnitude of the shift decreases on prolonged exposure.

Explanation of the Effect: A number of carefully controlled experiments will have to be conducted before other than a tentative explanation can be offered. It would appear, however, from the results of the experiments described above that thermal strain is the most probable cause. Further weight is given to this theory by the following observations using entry ports of various designs. If the metal electrode with a single, quarter inch port is replaced by one with a number of small ports distributed randomly over the entire surface, the magnitude of the anomaly is reduced. If it is replaced by a screen grid so that almost the entire surface of the crystal is uniformly exposed, what anomaly remains is so slight that it is difficult to detect.

The authors are indebted to Mr. Virgil E. Bottom for carrying out some of the preliminary experiments.

² Bertsch, C. V., Personal communication.

DETERMINATION OF XENOTIME

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ABSTRACT

The rare yttrium phosphate, xenotime, has been recognised in river sands in North Westland, New Zealand. The optical properties of this mineral have been determined and they are compared with those of minerals with which xenotime might possibly be confused. It is shown that the positive diagnosis of xenotime is not as difficult a task as is suggested by a number of writers.

OCCURRENCE AND MORPHOLOGICAL FEATURES

During a recent mineralogical study of concentrates obtained from dredges working river alluvium in the Grey River—Mawheraiti River area, of North Westland, New Zealand—the rare phosphate, xenotime, was recognised; this mineral is an accessory or minor constituent of an assemblage that includes among other minerals, colorless zircon, hyacinth, ilmenite, spessartite-almandine, monazite, and tantalum-cassiterite.

The yttrium phosphate almost invariably occurs in short prisms showing a combination of m (110) with z (111). Rarely the form a (100) was noted in combination with m (110), but the latter form is always dominant. Infrequently a basal plane has been developed, and such crystals may orient themselves in the mounting medium so that they exhibit excellent centered uniaxial interference figures. However, this simple habit of the xenotime crystals contrasts sharply with the complex combination of forms so characteristic of the colorless zircons associated therewith. For most of the grains a slight degree of rounding was not sufficient to prevent identification of the forms developed.

Determination of the refractive indices in sodium light by the immersion method gave the following values:

$$\begin{aligned}\alpha &= 1.720 \pm 0.005. \\ \gamma &= 1.827 \\ \gamma - \alpha &= 0.107.\end{aligned}$$

The mineral is uniaxial and optically positive; in the larger grains an exceedingly faint dichroism was detectable according to the scheme:

$$\begin{aligned}\text{X} &= \text{very pale yellow.} \\ \text{Z} &= \text{very pale yellowish-green.}\end{aligned}$$

The colours were so weak that it was not possible to determine the intensity of absorption along X or Z with any degree of accuracy. Grains of xenotime did not fluoresce when exposed to ultra-violet radiation.

Grains that pass a 230-mesh U.S.S. screen (aperture=62 microns),

appear to be quite colourless when immersed in refractive index liquids, but in oblique illumination under a binocular microscope, a very delicate yellowish-green colour is discernible for xenotime, a tint that contrasts quite distinctly with the more yellow colour of the associated monazite. Although in all examples examined, xenotime appears to be devoid of the dusty alteration products that appear to be so frequently developed on the surface of this mineral (Weinschenk-Clark, 1912, p. 232; Milner, 1940, p. 353), dust-like opaque inclusions were noted in a number of grains. These could not be diagnosed with certainty but they are suspected to be magnetite, for they were readily soluble when finely crushed xenotime was treated with warm 5 N.HCl, and the solution gave a strong reaction for iron. The identity of some deep brown, semi-opaque inclusions could not be determined.

Xenotime, even when free from inclusions, is moderately paramagnetic and in an electro-magnetic grading it was concentrated entirely with the monazite fraction. Qualitative chemical tests verified the presence of abundant yttrium* and phosphorus.

A comparison of the optical properties, determined by the writer, with those that have been recorded for xenotime by Winchell (1933, p. 138), Milner (1940, p. 353), and Larsen and Berman (1934, p. 73), leaves no doubt as to the identification, although the value for γ in the New Zealand mineral is slightly greater than that previously recorded.

It was found that the diagnosis of xenotime by optical methods alone was, therefore, not necessarily such a difficult problem as has been indicated by Milner (1940, p. 354), Whitworth (1932, pp. 67-68), and many others, who have particularly stressed the invariable morphological and optical resemblance to zircon. Whereas there is little difference morphologically between crystals of xenotime and zircon of simple habit, some of the optical properties are quite distinct, and there should not be any necessity to have to resort to spectrographic methods for confirmation. Admittedly some difficulty might arise in the diagnosis of minute grains in a rock slice, but in heavy mineral residue investigations where free grains are available, immersion in methylene iodide ($n=1.738$), or methylene iodide-sulphur ($n=1.788$ approx.), should assist in leaving the determination in little doubt. On the other hand, the birefringence of xenotime is so much greater than that of zircon, that differentiation of the two minerals is possible after a little experience, even when they are immersed in Canada balsam, or clove oil ($n=1.54$ approx.). Furthermore, confusion with titanite should not result owing to the very marked dispersion and the greater refractive index of the latter mineral.

* For method used here see: *The Analysis of Minerals and Ores of the Rarer Elements*. W. R. Schoeller and A. R. Powell, 2nd Ed., p. 83 (1940).

In the initial stages of the writer's work, however, some difficulty in the diagnosis of xenotime arose owing to the presence of grains of monazite that are nearly colourless when less than 62 microns in diameter, and are characteristically tabular parallel to the orthopinacoid. These monazite particles have been slightly rounded by abrasion and as a result the superficial appearance is similar to that of xenotime, or for

TABLE 1. OPTICAL DATA OF ZIRCON, XENOTIME, AND MONAZITE

| Mineral or mounting medium | α | β | γ | n_D (approx.) | $\gamma - \alpha$ | References |
|----------------------------|-------------|-------------|-------------|-----------------|-------------------|--|
| Zircon | 1.936 | — | 1.991 | — | 0.055 | Milner (1940, p. 354); Winchell (1933, p. 184); Larsen & Berman (1934, p. 75). |
| Zircon | 1.926 | — | 1.985 | — | 0.059 | Larsen & Berman (1934, p. 75). |
| Zircon | 1.924 | — | 1.968 | — | 0.044 | Ford (1921, p. 521); Iddings (1906, p. 416). |
| Zircon | 1.923-1.960 | — | 1.968-2.015 | — | 0.045-0.055 | Ford (1932, p. 611). |
| Zircon | 1.925-1.931 | — | 1.985-1.993 | — | 0.060-0.062 | Rogers & Kerr (1942, p. 306). |
| Zircon | 1.960 | — | 2.015 | — | 0.055 | Iddings (1906, p. 416). |
| Zircon | 1.9313 | — | 1.9931 | — | 0.0618 | Weinschenk-Clark (1912, pp. 350-351). |
| Xenotime | 1.721 | — | 1.816 | — | 0.095 | Milner (1940, p. 354); Ford (1932, p. 700); Larsen & Berman (1934, p. 73). |
| Xenotime | not stated | — | not stated | — | high as in zircon | Iddings (1906, p. 482). |
| Xenotime | 1.7207 | — | 1.8155 | — | 0.0948 | Winchell (1933, p. 138). |
| Xenotime | 1.720 | — | 1.827 | — | 0.107 | Westland, Hutton (this work) |
| Monazite | 1.787-1.800 | 1.788-1.801 | 1.837-1.849 | — | 0.045-0.055 | Winchell (1933, p. 139); Larsen & Berman (1934, p. 138); Rogers & Kerr (1942, p. 223); Krumbein & Pettijohn (1938, p. 437). |
| Monazite | 1.786 | 1.788 | 1.837 | — | 0.051 | Ford (1932, p. 701) |
| Monazite | 1.7957 | 1.7965 | 1.8411 | — | 0.0454 | Iddings (1906, p. 482). |
| | 1.7863 | 1.7879 | 1.8373 | — | 0.0510 | |
| Monazite | 1.800 | 1.801 | 1.849 | — | 0.049 | Milner (1940, p. 314). |
| Monazite | 1.785 | 1.787 | 1.840 | — | 0.055 | Gordon (1939, p. 7). |
| Monazite | 1.787 | 1.789 | 1.839 | — | 0.052 | Westland, Hutton (this work). |
| Clove oil | — | — | — | 1.54 | — | — |
| Methylene iodide | — | — | — | 1.738 | — | — |
| Methylene iodide-sulphur | — | — | — | 1.788 | — | — |
| Tetra-iodo-acetylene | — | — | — | 1.81 | — | — |
| Phenyl-di-iodoarsine | — | — | — | 1.843 | — | — |

that matter, of slightly abraded zircons. Owing to the crystallographic development most of the grains of monazite tend to lie on the orthopinacoid and since the optic axial plane is almost parallel to (100), such crystals normally exhibit very nearly the maximum birefringence for that mineral. The refractive indices of Westland monazite, containing 5.32% ThO₂, are rather lower than those often recorded for monazites ($\alpha=1.787$, $\beta=1.789$, $\gamma=1.839$; $\gamma-\alpha=0.052$), but are similar to those determined by Gordon (1939, p. 7) for a thorium-free specimen from Bolivia. Thus in clove oil or in Canada balsam differentiation of almost colorless monazite from zircon or xenotime might be uncertain, but inspection of assemblages containing these minerals in methylene iodide or methylene iodide-sulphur mixtures enables accurate diagnoses to be made.

A summary of the distinctive properties of xenotime, monazite, and colourless, or pale yellow zircon, is set out in Table 1, and the refractive indices of a number of standard immersion media employed in heavy mineral identifications have been added.

Careful searching of a number of concentrates from New Zealand and foreign sources has shown xenotime to be present, and it is believed that this mineral is by no means the rarity that it has generally been considered. Therefore the writer would like to stress the very real necessity for the use of high refractive liquids and mounting resins, when heavy mineral assemblages are being studied, otherwise recognition of a number of minerals may be difficult if not impossible.

For a preliminary investigation of heavy mineral assemblages the following procedure has been found to be most useful and is appended herewith in the hope that it may assist other investigators on such problems:

1. Screen the heavy mineral fraction; the screens most used are U.S.S. Nos. 60, 120, and 230, with mesh diameters of 250, 125, and 62 microns, respectively.
2. Mount a portion of each fraction after careful splitting in Canada balsam ($n=1.54$) and in hyrax ($n=1.70$) for permanent reference and study.
3. A complete and thorough investigation of the mineral assemblages requires that portions of each screening should be examined in α -monobromnaphthalene ($n=1.65$), methylene iodide ($n=1.738$), methylene iodide-sulphur ($n=1.788$), tetra-iodo-acetylene ($n=1.81$), and possibly phenyl-di-iodoarsine ($n=1.84-1.85$).

REFERENCES

- FORD, W. E. (1922), *A Textbook of Mineralogy*, 3rd ed., John Wiley & Sons, Inc., New York.

- (1933), *A Textbook of Mineralogy*, 4th ed., John Wiley & Sons, Inc., New York.
- GORDON, S. G. (1939), Thorium-free monazite from Llallagua, Bolivia: *Notulae Naturae Acad. Nat. Sci. Philadelphia*, No. 2, 1-7.
- IDDINGS, J. P. (1906), *Rock Minerals, Their Chemical and Physical Characters and Their Determination in Thin Sections*, 1st ed., John Wiley and Sons, New York.
- KRUMBEIN, W. C., AND PETTIJOHN, F. J. (1938), *Manual of Sedimentary Petrography*, D. Appleton-Century Co., Inc., New York.
- LARSEN, E. S., AND BERMAN, H. (1934), The Microscopic Determination of the Nonopaque Minerals, 2nd ed.: *U. S. Geol. Surv., Bull.* 848.
- MILNER, H. B. (1940), *Sedimentary Petrography*, 3rd ed., Thomas Murby & Co., London.
- ROGERS, A. F., AND KERR, P. (1942), *Optical Mineralogy*, 2nd ed., McGraw-Hill Book Co., Inc., New York.
- WINCHELL, A. N. (1933), *Elements of Optical Mineralogy*, pt. 2, 3rd ed., John Wiley & Sons, Inc., New York.
- WHITWORTH, H. F. (1932), The mineralogy and origin of the natural beach sand concentrates of New South Wales: *Jour. Roy. Soc. New South Wales* for 1931, 62, 59-74.
- WEINSCHENK, E., AND CLARK, R. W. (1912), *Petrographic Methods*, McGraw-Hill Book Co., Inc., New York.

SYNTHESIS OF NORBERGITE AND CHONDRODITE BY DIRECT DRY FUSION

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ABSTRACT

Experiments were carried out in order to study the synthetic preparation of the minerals of the humite group by a single crystallization from a dry melt. The reaction products were identified by their optical properties and x -ray powder photograms. Below the melting temperature of magnesium fluoride the reaction between this compound and forsterite took place in a solid state. Artificial norbergite and chondrodite were obtained in which the hydroxyl groups were completely replaced by fluorine. The products were nearly or completely iron-free. Attempts to synthesize clinohumite and certain hypothetical upper members of the family failed, pure magnesium orthosilicate being obtained instead. Norbergite, chondrodite, and sellaite crystallized from a melt with a composition between sellaite and norbergite.

INTRODUCTION

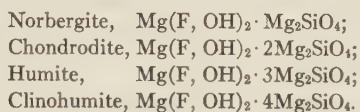
Contrary to many common rock minerals which have been repeatedly prepared by the successful efforts of mineralogists and mineral chemists, the humite group, up to the present, seems to have gained only slight attention. The earliest attacks upon this problem were made by the famous French school of mineral chemists, nearly a century ago. Thus, Daubrée (1851, p. 627), by passing SiF_4 over MgO in a porcelain tube at dark-red heat, obtained a fibrous fluorine-bearing silicate, with a specific gravity equal to that of chondrodite, and showing a close chemical analogy with the last-mentioned mineral. Sainte-Claire Deville (1861), on the other hand, under similar circumstances reported only the formation of vitreous or crystalline silicates with a composition entirely different from that of chondrodite and humite.

In 1889 Doelter, in an important paper on mica synthesis, reported the occurrence of what he thought to be chondrodite in one of the experiments yielding no mica (1889, pp. 70–71). The synthesis was accomplished by dry fusion of actinolite (“Strahlstein”), nearly or totally devoid of alumina, with calcium fluoride and a little sodium fluoride. This result further led him to fuse Mg_2SiO_4 with a 5-fold amount of MgF_2 and a little Na_2F_2 . The experiment resulted in the formation of yellow-brown rectangular grains, thought possibly to be humite (*op. cit.*, p. 72).

The next attack upon the problem was made by Jander and Fett in 1939. These authors carried out a series of hydrothermal experiments in bombs at different temperatures (360° to 600° C.) and pressures, starting from a mixture of the oxides MgO and SiO_2 with $\text{H}_2\text{O} + \text{H}_2\text{F}_2$, or MgF_2 . The reaction products were identified by their x -ray diffraction patterns.

Jander and Fett claim that the presence of a minimum of 6% F_2 is necessary for the hydrothermal formation of chondrodite (1939, p. 158). Humite was also obtained by these authors in their experiments.

The chemical composition and atomic arrangement of the minerals of the humite group reveal interesting examples of close morphotropic and chemical relations existing between its members. Through the classical studies of Sjögren and of Penfield and Howe, and by Geijer's discovery of norbergite as the first member of the series, the chemistry of this group can be presented in the following way:



The crystal structures of the members of the humite group have been investigated by Taylor and West. They consist of slabs of the olivine structure and of magnesium hydroxide alternating with each other. In norbergite layers of $\text{Mg}(\text{OH})_2$ alternate with layers of Mg_2SiO_4 . In chondrodite two slabs of Mg_2SiO_4 are followed by one $\text{Mg}(\text{OH})_2$, in humite every fourth slab is $\text{Mg}(\text{OH})_2$, and in clinohumite every fifth slab. In natural humite minerals part of Mg^{2+} is always diadochically replaced by Fe^{2+} and by Mn^{2+} , and a part of OH^- by F^- .

As the construction of the idealized structures of the humite minerals can be carried out merely by stacking together unit blocks of Mg_2SiO_4 and $\text{Mg}(\text{OH})_2$, it was thought to be worthwhile to try to carry out the synthesis of the minerals proper by direct coupling of the lattice units. Seeing that OH^- in these lattices is partly replaced by F^- , experiments were carried out in order to try to produce hydroxyl-free members of this group by dry fusion of forsterite and magnesium fluoride at atmospheric pressure. The synthetic minerals, if obtained, were thought to be comparable with the fluorine-bearing amphiboles produced by Bowen and Schairer (1935), and with similar phlogopites and hornblendes obtained by Grigoriev (1934, 1935), and by Grigoriev and Isküll (1937). In case of humite minerals, however, attention must be paid to the fact that the $\text{Mg}(\text{OH})_2$ has a lattice of the cadmium iodide type, while MgF_2 has the symmetrically coordinated rutile structure. The complete replacement of OH^- by F^- in the lattice would thus be expected to correspond to a decrease in polarization.

APPARATUS AND REAGENTS

The forsterite used in the experiments was obtained from a dunite sample from Almklovdaalen in Søndmøre, Norway. The mineral was

separated from the crushed rock sample by means of Clerici solution. Its properties were determined as follows:

| | |
|---|--------------------|
| FeO | 6.67% |
| MnO | 0.07% |
| Sp. gr. | 3.199–3.202 |
| | $\alpha = 1.648$ |
| | $\beta \sim 1.669$ |
| | $\gamma = 1.688$ |
| Composition: $\text{Fo}_{90}\text{Fa}_{10}$. | |

A magnesium fluoride preparation ("gefällt, doppelt gereinigt") of Riedel-de Haën, Berlin, was used. The determination of its properties gave the following results:

| | |
|-----|----------------------|
| FeO | 0.12% |
| MnO | 0.00% |
| | $\omega = 1.377$ |
| | $\epsilon = 1.388$. |

In all, 16 fusions were carried out. For the first experiments, 1–3, a high temperature furnace with silicon carbide heating units was used, and the charges were placed in platinum crucibles. The temperatures were measured with a Pt-PtRh thermoelement. All other fusions were carried out in a cryptole furnace in small graphite crucibles. In this case, the temperatures were measured with an optical pyrometer. In all these experiments the charge was heated to 1600°–1700° C., and the values given below will represent the average temperatures in this range. One gram of forsterite was weighed out for every fusion, and an amount of MgF_2 , calculated to give the charge the desired composition, was carefully mixed with the former. After the fusion, the crucible was allowed to cool down in the furnace. The reaction products were studied in thin sections. Refractive indices of the compounds formed were determined by the immersion method. The error in these determinations is ± 0.002 . In addition, axial angles were determined with the universal stage when possible, with an error of $\pm 2^\circ$. The compounds were identified by comparing their x -ray powder photograms with those of the natural minerals.

EXPERIMENTS

2. A mixture with the composition of norbergite was heated for 1 hr. at 1290° C. and allowed to cool down in the furnace for 1 hr. The product obtained was a loose light brown powder. Forsterite and magnesium fluoride had completely disappeared. The mass was homogeneous, and the determination of the refractive indices gave: $\alpha > 1.550$, $\gamma < 1.595$. The diffraction pattern obtained from the reaction products was identical with that of natural norbergite.

3. The composition of the charge was the same as in Exp. 2. Now, the mixture was heated for 2 hrs. at 1350°C . and allowed to cool down as above. The reaction product consisted of a partly sintered light brown powder with refractive indices: $\alpha > 1.550$, $\gamma < 1.595$. The product was homogeneous and the powder photograms proved the presence of norbergite.

6. A third charge of norbergite was heated for 2 hrs. at 1620°C . and allowed to cool down overnight. The cake was crystalline and consisted of white lath-shaped crystals up to 2 mm. long. Megascopically, small blebs of graphite could be distinguished in the mass. The parts of the cake next to the walls and the bottom of the crucible contained small rounded iron globules. The hardness of the crystals was approximately 6. They did not gelatinize, or dissolve, when treated with boiling concentrated or dilute hydrochloric acid. The determination of the refractive indices revealed the presence of three different phases with the following indices:

$$(1) \alpha = 1.564, \quad \beta \sim 1.567, \quad \gamma = 1.592;$$

$$(2) \alpha \sim 1.591, \quad \gamma \sim 1.630;$$

$$(3) \alpha \sim 1.641, \quad \beta \sim 1.655, \quad \gamma = 1.667.$$

The greatest part of the reaction products consisted of the phases (1) and (2), amounting to approximately 40% and 50% of the total mass, respectively, while the amount of the third phase was about 10% of the total mass.

In thin section the mass was found to consist of colorless subhedral or anhedral lath-like crystals measuring from 0.02 to 2.3 mm. in length. One poorly-developed direction of cleavage, parallel to the elongation of the crystals, was found in some cases. Hematite blebs were present, and narrow graphite and hematite strings, parallel to the elongation, were often found in the crystals. Two different phases were easily distinguished under the polarizing microscope, one of them with extinction parallel to the elongation; in the other, the maximum elongation angle observed, as measured from the trace of the outline, was 30° . Twinning was present in many grains; the twinning plane was parallel to the elongation. Sometimes laths with higher refractive indices and inclined extinction were found to be surrounded by a shell with lower refraction and parallel extinction. The axial angle, $2V_{\gamma}$, of the latter was 44° while that of the kernel was large. All the phases were optically biaxial, positive. The x-ray diffraction pattern of the reaction products was exceedingly similar to those of natural norbergite and chondrodite. From the above properties, the products consist of norbergite, chondrodite, and forsterite.

12. Still another norbergitic charge was treated as in Exp. 6. Also in this case the cake was crystalline, but the crystals were smaller than in

the previous experiment. Only in the part next to the bottom of the crucible could small white subhedral laths be seen in the cake; while the upper portion consisted of a white mass of small anhedral grains, with occasional blebs of graphite and layers of hematite, which were parallel to the surface of the charge and gave the whole a herringbone structure. On the free surfaces the cake had a pearly luster. Small iron globules adhered to the surfaces close to the walls of the crucible. The hardness of the cake was about 6. The determination of the refractive indices again revealed the presence of three compounds, viz.

80% with $\gamma \sim 1.590$,
5% with $\gamma \sim 1.630$,
15% with $\gamma \sim 1.668$.

The percentages are approximate.

In thin section, a few subhedral laths were found, measuring up to 0.7 mm. in length. They were biaxial, positive, and sometimes twinned, the twinning plane being parallel to the elongation. One poorly developed cleavage direction, parallel to the elongation, was occasionally observed. The axial angle was large. The maximum extinction angle observed, as measured from the trace of elongation, was 24° . The main part of the material, however, was present as small anhedral grains of uniform orientation, their elongation being vertical to the bottom of the crucible. The extinction was parallel to the elongation. The diffraction pattern was, again, similar to those of natural norbergite and chondrodite. To judge by their properties, the reaction products include norbergite, chondrodite, and forsterite.

7. The charge of this experiment had the composition of chondrodite. It was heated for 3 hrs. at 1640°C . and allowed to cool down for 5 hrs. The resulting cake was coarsely crystalline and consisted of white lath-shaped crystals with a hardness of about 6. They were not decomposed when boiled with dilute or concentrated HCl. Graphite and occasional pellets of iron adhered to the parts next to the crucible.

Under the polarizing microscope the mass was found to consist of colorless elongated lath-like crystals, some of which were euhedral and showed the characteristic olivine-like outline. In these extinction was parallel to the elongation. The length of all grains was between 0.4 and 0.8 mm. The major part consisted of subhedral laths, with occasional twinning and cleavage cracks parallel to the elongation. The maximum extinction angle observed in these grains, measured as in previous cases, was 14° . Both compounds were biaxial, positive, and the axial angle of the latter, $2V_\gamma$, was 68° – 70° . The interstices of the laths consisted of small anhedral grains with somewhat lower refractive indices, finely

disseminated graphite, and hematite. The determination of the refractive indices gave the reaction products the following approximate composition:

| | | |
|--------------------------------|----------------------|-----------------------|
| 10% with | | $\gamma \sim 1.620$; |
| 60% with $\alpha \sim 1.611$, | $\beta \sim 1.620$, | $\gamma = 1.640$; |
| 30% with | $\beta \sim 1.654$, | $\gamma \sim 1.668$. |

The x -ray powder photogram of the reaction products was similar to that obtained from natural chondrodite. According to their properties the reaction products consist of chondrodite and forsterite.

9. Another charge with the composition of chondrodite was heated for 2 hrs. at 1600° C. and allowed to cool down for 3 hrs. The products consisted of white lath-shaped crystals, this time with many inclusions consisting of small pellets of iron, blebs of graphite and, occasionally, hematite. Megascopically, the cake had a gray color. In thin section, the silicate material was found to form a colorless irregular mass of subhedral lath-like crystals with a maximum length of 0.7 mm. A few cleavage cracks parallel to the elongation of the laths were observed. No twinning was present. Some of the grains had extinction parallel to the elongation, while in other grains the maximum extinction angle observed, measured from the trace of elongation and of the cleavage cracks, was 33° . All the material was optically biaxial and positive. The determination of the axial angle of some grains gave $2V_{\gamma}$ of 72° – 74° . The refractive indices for the main portion of the material were: $\alpha = 1.607$, $\beta = 1.620$, $\gamma = 1.640$. In addition, material was present with $\gamma \sim 1.665$. The powder photograms of the reaction products were identical with that of natural chondrodite. The reaction products evidently consist of chondrodite and a little forsterite.

8. The charge had the composition of clinohumite. It was heated for 3 hrs. at 1650° and allowed to cool down overnight. The cake consisted of small white irregularly shaped crystals, not acted upon by hydrochloric acid. Inclusions of metallic iron, graphite, and hematite were present. In thin section, a network was visible, consisting of short subhedral colorless laths 0.2 to 0.3 mm. in length, and containing numerous inclusions of the material stated above, as blebs or finely disseminated matter. Cleavage cracks parallel to the elongation were sometimes present. No twinning could be established. The extinction was parallel to the elongation. The material was biaxial, positive, with a large axial angle. Its refractive indices were: $\alpha = 1.633$, $\beta = 1.644$, $\gamma = 1.664$. The powder pattern given by the reaction product corresponded with that of forsterite. By its properties, the compound obtained in this experiment is magnesium orthosilicate.

10. Another charge of clinohumitic composition was heated for 2 hrs. at 1640° C. and allowed to cool down overnight. Megascopically, short lath-shaped white crystals, graphite, and metallic iron were found to be present in the cake after fusion. The cake was quite brittle, and no thin section of it could be prepared. The determination of the refractive indices yielded the following results: $\alpha = 1.632$, $\beta = 1.644$, $\gamma = 1.664$. The powder pattern was similar to that of forsterite. The reaction product, according to its properties, is magnesium orthosilicate.

15. The charge had, again, the composition of clinohumite. It was heated for 2 hrs. at 1600° C. and allowed to cool down overnight. The properties of the reaction products were similar to those in the previous experiment. The determination of the refractive indices revealed the presence of two compounds, viz.

$$\begin{array}{l} 5\% \text{ with } \alpha \sim 1.610, \\ 95\% \text{ with } \alpha = 1.631, \quad \beta = 1.644, \quad \gamma = 1.663, \end{array}$$

the percentages being approximate. The powder diffraction pattern was similar to that of forsterite. The reaction products consist of magnesium orthosilicate, with minor amounts of chondrodite.

In order to study the possibility of obtaining hypothetical members of the humite group, some of which have been supposed to exist according to Bragg (1937, p. 153), the following experiments were carried out, starting with smaller and greater amounts of forsterite than is known to enter into the formulas of the known minerals in this group.

16. The charge had the composition $\text{MgF}_2 \cdot \frac{1}{2} \text{Mg}_2\text{SiO}_4$. It was heated for 2 hrs. at 1600° C. and allowed to cool down overnight. Megascopically, the cake was composed of white lath-shaped crystals with hematite and graphite blebs, and a large number of iron globules on the surfaces next to the walls of the crucible. The crystals were neither gelatinized, nor dissolved, when treated with boiling hydrochloric acid.

Three different crystalline substances were found to be present in a thin section of the cake. The mass consisted of colorless slender subhedral laths, ranging from 0.06 to 3.9 mm. in length, and of smaller more euhedral rectangular grains with the form of thick prisms. Twinning was often present, especially in the smaller grains, and cleavage cracks parallel to the elongation of the grains were usually observed. By the determination of the extinction angles the presence of two different substances was established, one of which had extinction parallel to the elongation, while the maximum extinction angle observed in the other, measured as in the above experiments, was 33° . Both compounds were often intergrown, in which case the center of the grain was usually twinned and had inclined extinction and higher refraction, while the shell consisted

of material with parallel extinction and lower indices of refraction. Both were biaxial, optically positive. The axial angle, $2V_\gamma$, of the former compound was 63° , and that of the latter one 42° – 48° . The determination of the refractive indices gave following results:

- (1) $\alpha \sim 1.552$, $\beta \sim 1.560$;
- (2) $\alpha \sim 1.575$, $\beta = 1.588$, $\gamma = 1.604$.

The main part of the reaction products consisted of the substance with the lower refraction.

The interstices between the laths were filled with small anhedral grains and their aggregates, characterized by their high negative relief.

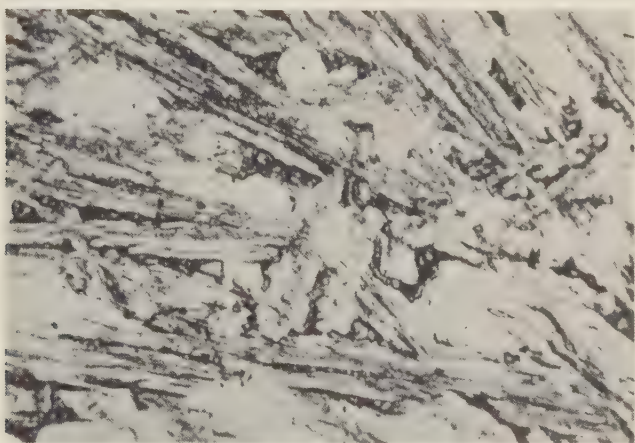


FIG. 1. Laths of synthetic norbergite and chondrodite (light gray) with irregular grains of sellaite (dark gray) in thin section. Exp. 16. Magn. $27\times$. 1 nicol.

A few grains were observed which developed forms similar to a four-pointed star. This compound was optically uniaxial, positive. According to its properties, it is recrystallized magnesium fluoride, or sellaite.

A photomicrograph of the reaction products is presented in Fig. 1.

From the x -ray powder photogram, the presence of magnesium fluoride could be further established among the reaction products, while the pattern in other respects was similar to that yielded by natural norbergite. From the above properties, the reaction products consist of norbergite, chondrodite, and sellaite.

11. A mixture with the composition of $\text{MgF}_2 \cdot 8\frac{1}{2} \text{Mg}_2\text{SiO}_4$ was heated for 2 hrs. at 1640°C . and allowed to cool down overnight. The reaction products consisted of small white crystals, iron pellets, and graphite, as

in the above experiments. The last-mentioned mineral, as small inclusions in the mass, was quite common. The determination of the refractive indices of the crystals gave: $\alpha=1.633$, $\beta\sim 1.644$, $\gamma=1.663$. The powder photogram of the substance was similar to that of forsterite. The above properties reveal the reaction product to consist of this compound.

14. A charge of similar composition as in Exp. 11 was heated for 2 hrs. at 1600°C ., and allowed to cool down overnight. Megascopically, the cake was composed of small white crystals with inclusions of iron, hematite, and graphite. Due to the numerous inclusions, the color of the cake was gray. In thin section, it was found to consist of colorless crystalline matter with much opaque material. The crystalline substance was present in form of usually small anhedral (length 0.02 to 0.14 mm.) grains. The outlines of the more well-developed grains were similar to those of olivine crystals. Neither cleavage or twinning was present; the extinction was parallel to the elongation, and the crystals were biaxial, positive. The determination of the refractive indices gave: $\alpha=1.633$, $\beta\sim 1.645$, $\gamma=1.663$. The axial angle, $2V_{\gamma}$, was 80° – 84° . The x -ray diffraction photogram proved the presence of forsterite.

13. In this experiment, the charge was highly forsteritic, with the composition $\text{MgF}_2 \cdot 17\text{Mg}_2\text{SiO}_4$. The mixture was heated for 2 hrs. at 1600°C . and left to cool down overnight. The cake consisted of very small white crystals. Due to the occurrence of numerous graphite and iron inclusions, the mass had a dark gray color. The determination of the refractive indices yielded the following values: $\alpha=1.633$, $\beta=1.644$, $\gamma=1.664$. The x -ray diffraction pattern of the reaction products was similar to that of forsterite, thus proving the presence of this compound as resulting from the experiment.

DISCUSSION OF RESULTS

The experiments described above seem to make apparent that, in some cases at least, it is possible to produce synthetic minerals belonging to the humite group by simple crystallization from a dry melt. As the products are different from the natural minerals which always contain hydroxyl groups, replacing a part of the fluorine, it seems to be appropriate to call the water-free synthetic products obtained fluor-norbergite and fluor-chondrodite, respectively. No experiments have been made with melts of the composition of humite. The attempts to produce clinohumite and certain hypothetical upper members of the group have thus far failed, magnesium orthosilicate being obtained instead. In these cases the amount of MgF_2 present was too small to produce an easy melting of the charge, as is seen by the properties of the reaction products

and by the incomplete separation of the metallic phase. It seems to be evident, from these experiences, that the artificial preparation of clinohumite, if at all possible, must be tried at temperatures exceeding that necessary for the melting of forsterite.

It also seems to be apparent that the reaction between forsterite and magnesium fluoride will take place even at temperatures below the melting points of these compounds. Thus, in experiments 2 and 3, these components disappeared during the heating of the charge for one or two hours at 1290°–1350°, norbergite being formed instead. The reaction has evidently taken place in a solid state.

To judge from the above experiments, there seems to occur a general tendency towards an easier crystallization of the silicate phase, and a more complete separation of the reduced iron phase, with an increase in the MgF_2 content of the melt.

An explanation of the simultaneous formation of the humite minerals with different compositions and, likewise, of magnesium orthosilicate in melts with clinohumitic composition, may be found in the occurrence of metallic iron among the reaction products. In the highly reducing atmosphere in the furnace, the iron present in the forsterite lattice is reduced to metal and, thereby, an excess in SiO_2 in the melt is brought about. The iron is removed, in most cases evidently completely, and pure magnesium compounds crystallize from the melt. As the composition of the charges was calculated under assumption that a diadochic replacement of Mg^{2+} by Fe^{2+} would result in the reaction products, the mineral composition of the crystallized melt is often more complicated than can be expected from the composition of the charge. In experiments yielding only forsterite, an excess of MgF_2 was present in the melt. As renewed checking of the refractive indices of the reaction products did not reveal the presence of any grains with indices below 1.500, it must be assumed that MgF_2 either has escaped from the melt or is camouflaged by graphite abundantly present in the cakes; or, that a reaction has taken place between magnesium fluoride and carbon, leading towards the formation of magnesium carbides.

Special attention must be paid to Exp. 16. Here the reaction products consisted of fluor-norbergite with minor amounts of fluor-chondrodite. The excess of MgF_2 , in this case, crystallized from the melt in the form of sellaite. Consequently, no intermediate step between sellaite and norbergite seems to be possible.

No direct comparison of the refractive indices can be made between the natural humite minerals and those artificially produced, due to the lack of chemical analyses in the latter case. As to the natural humite minerals,

Larsen (1928, pp. 354–359) found a tendency towards a decrease in the indices of refraction with the increase in the fluorine content. A similar conclusion was made also by the present writer (Rankama, 1938, p. 91), on a later occasion. In the amphibole group, Bowen and Schairer (1935, p. 549) noted that the refractive indices of synthetic fluor-amphiboles are lower than those in the hydroxy-amphiboles. Their observation was further verified by Grigoriev and Isküll (1937, p. 173), in regard to a regenerated amphibole rich in fluorine.

In the present case, all the products obtained are completely devoid of water. Consequently, nothing can be said as to the effect of fluorine and water on the refractive indices in the humite group. The indices of refraction of synthetic magnesium fluor-norbergite agree with the values given in literature for the natural mineral, and thus would indicate that the iron compounds were not completely reduced. In Exp. 16, on the other hand, the exceptionally low refractive indices of both norbergite and chondrodite may be explained by the complete reduction of the iron compounds to metallic iron.

The magnesium orthosilicate obtained in the experiments is evidently very pure, to judge from its optical properties. Its indices of refraction are decisively lower than those of the forsterite used in the fusions. In experiments yielding magnesium orthosilicate as the main or single component, the refractive indices seem to be even a little lower than those reported in the handbooks for pure magnesium orthosilicate. This would, perhaps, suggest a partial replacement of O^{2-} by F^- in the lattice.

By the complete replacement of the hydroxyl groups in the lattices of norbergite and chondrodite by fluorine, the chemical resistance power of the compounds evidently will increase. The synthetic fluor-norbergite and fluor-chondrodite are insoluble in hydrochloric acid of any concentration, while the natural humite minerals are easily gelatinized by this acid.

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REFERENCES

- BOWEN, N. L., AND SCHAIRER, J. F., Grunerite from Rockport, Massachusetts, and a series of synthetic fluor-amphiboles: *Am. Mineral.*, **20**, 543 (1935).
- BRAGG, W. L., *Atomic Structure of Minerals*. Ithaca, N. Y. (1937).
- DAUBRÉE, A., Expériences sur la production artificielle de l'apatite, de la topaze, et quelques autres métaux fluorifères: *C. R.*, **32**, 625 (1851).
- DOELTER, C., Ueber Glimmerbildung durch Zusammenschmelzen verschiedener Silicate mit Fluormetallen, sowie über einige weitere Silicatesynthesen: *Min. Petr. Mitt.*, **X**, 67 (1889).
- GRIGORIEV, D. P., Künstliche Darstellung der Magnesiumglimmer: *Zentr. Min., Abt. A*, 219 (1934).
- GRIGORIEV, D. P., Über die Kristallisation von Hornblende und Glimmer aus künstlichen Silikatschmelzen: *Zentr. Min., Abt. A*, 117 (1935).
- GRIGORIEV, DMITRY P., AND ISKÜLL, ELLEN W., The regeneration of amphiboles from their melts at normal pressure: *Am. Mineral.*, **22**, 169 (1937).
- JANDER, WILHELM, UND FETT, REINHOLD, Hydrothermale Reaktionen. II. Mitteilung. Magnesiumhydrosilikate. II: *Zeit. anorg. allg. Chem.*, **242**, 145 (1939).
- LARSEN, ESPER S., The optical properties of the humite group: *Am. Mineral.*, **13**, 354 (1928).
- RANKAMA, KALervo, On the mineralogy of some members of the humite group found in Finland: *C. R. Soc. géol. Finlande*, **12**; *Bull. Comm. géol. Finlande*, **123**, 81 (1938).
- SAINTE-CLAIRE DEVILLE, H., Du mode de formation de la topaze et du zircon: *C. R.*, **52**, 780 (1861).

ALTERATION STUDIES*

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Mineralogy is rich in the lore of pure science. Lately, this heritage has been called upon for substantial aid in the service of the nation. In the years to come it seems likely that mineralogy will be asked to furnish even greater contributions. The purpose of this discussion is to outline but one of the major opportunities for further service which is now emerging on the post war horizon.

Mineral industry finds itself in somewhat of a dilemma. On the one hand, new mineral deposits are becoming more difficult to find. On the other, known deposits continue to be depleted ever more rapidly. The alternatives are simple. Either the rate of discovery must increase, or metals necessary to modern civilization will become economically unavailable.

Leaders are becoming aware of this situation, and increased emphasis is being placed upon the search for new methods of exploration. The techniques of engineering, physics, chemistry, geophysics, geology, and mineralogy are being scanned as never before to discover fundamental phenomena which may be applied in finding mineral deposits. A product of this survey of special interest to mineralogists, which has received particular impetus of late, is the study of rock alteration associated with ore deposition.

The term "alteration study" has been applied to the investigation of clays and other fine mineral aggregates often found within or near mineral deposits. Most frequently, the deposits considered contain copper, zinc, lead, silver, or other metals. Localities are found in and around many of the igneous intrusives of the western United States.

Areas of alteration which contain clay vary widely in their dimensions. Some may form an envelope a few feet in thickness along the walls of a vein. Others may comprise areas traceable for thousands of feet or even miles. Alteration phenomena occur in various rock types, but are perhaps most effectively studied when found in igneous masses. Stocks, flows, sills and dikes often provide the locale in which progressive clay-mineral alteration may be observed.

Suites of alteration minerals contain a variety of species, but delineation of zones or stages appears best established when attention is directed to a comparatively small number of the most significant species. The common clay minerals, sericite, jarosite, alunite, limonite, pyrite, various carbonates, and fine quartz are among the most significant.

* Address of the retiring President of The Mineralogical Society, delivered at the twenty-seventh annual meeting of the Society, Chicago, Illinois, December 26, 1946.

Where alteration is a weathering effect, or is entirely supergene, these studies have little application. On the other hand, where recognizable processes are hypogene the relationship of alteration to the formation of the ore minerals may be particularly significant. It is with the latter that we are most concerned.

The technique of alteration study is one of combined field and laboratory investigation. Field study includes careful geologic mapping with instrumental control and in sufficient detail to delineate significant alteration zones. Among the laboratory techniques employed, the two which are probably most useful are microscopic and *x*-ray examination. These two methods may be supplemented on occasion by chemical analysis, hydration study and frequently by differential thermal analysis. In some instances photographs with the electron microscope are desirable. For example, electron micrographs of halloysite are particularly significant.

Clay mineral techniques have been improving constantly since Ross and Shannon (1926) published their classic paper on the montmorillonite group. With the stimulus provided by early work numerous scientists in mineralogy and allied fields became active in furthering clay mineral studies. Due to the cumulative efforts of these investigators, the principal clay mineral groups have been established and much has been learned about their relationships and fundamental nature. As a result of modern studies the nomenclature of the clay minerals has been greatly clarified and many obscure and invalid species eliminated. The kaolin group has been established. Montmorillonite has become known as a group and has become better understood. The hydromica group, or as some say, the "illite" group, has received recognition. The relationships of subsidiary clay minerals to the chief groups and related species are becoming better established. Such progress in 21 years indicates that the clay minerals may now be said to be of age.

Although the clay minerals may have but recently become of age, the application of clay mineral technique to alteration studies has been in progress for several years. The need for coordinated field and laboratory investigation was emphasized by Mr. Reno Sales in an address delivered in 1938. He especially stressed the desirability of more research covering chemical changes in wall rocks associated with ore deposits. Mr. Sales has not only recognized a need but has taken active steps to work out a solution. Under his direction, Mr. Charles Meyers of the staff of the Anaconda Copper Co. has carried on studies of wall rock alteration associated with the veins at Butte, Montana. The laboratory at Butte has also contributed to alteration studies through the development of an improved technique in the cutting of thin sections of alteration mate-

rials, as described by Mr. Meyers. Large slices not much greater in thickness than a standard thin section are cut by a saw in a single operation.

Schroter and Campbell (1940) called attention to a clay deposit of hydrothermal origin. It consists of a large mass of halloysite which occurs in the workings of the Dragon Consolidated mine, in the Tintic district near Eureka, Utah. The writer visited the Dragon Consolidated mine during the summer of 1945 with Mr. Dudley Davis of the International Smelting and Refining Company. The deposit was originally mined for gold, but in recent years a considerable number of carloads of high grade halloysite have been shipped. The halloysite body occurs along the contact between a monzonite intrusive and Paleozoic sediments, where it marks a zone of hydrothermal alteration. Some distance away, lead-zinc ore bodies have been mined from the sediments along the same channel of mineralization.

One of the most active students of alteration has been Dr. T. S. Lovering. His earlier work in the Boulder, Colorado, tungsten district and more recent studies in the East Tintic district of Utah are of particular interest. Compared to some of the large zones of alteration in the copper districts of the west the alteration zones at Boulder are minor features. On the other hand, the symmetry of the alteration envelopes and the zonal grouping of the clay minerals provide criteria of more than local significance.

In the East Tintic district the alteration which has resulted in clay zones has long attracted attention. In places clay zones are so prominent that exploration ventures have been based in part at least on their existence. As a result of the work of Mr. Paul Billingsley, Dr. M. B. Kildale and others, important ore bodies have been found.

For several years Dr. Lovering and his associates have sought to apply alteration study techniques to geologic mapping in the East Tintic district. Through Dr. Lovering's kindness, the writer had an opportunity to spend several days with the East Tintic field party in the summer of 1945. The East Tintic studies have been directed in particular toward the observation of alteration in the Packard rhyolite together with a study of changes with depth or lateral changes at a given depth. Rhyolite forms a blanket lying uncomfortably above a considerable portion of the Paleozoic sediments in which ore bodies at times occur. Study of zones of alteration in both the rhyolite and sedimentary formations has been carried on to define centers of mineralization possibly worthy of exploration.

Two stages of alteration are recognized in the East Tintic studies: (1) an earlier barren stage and (2) a later productive stage. The barren stage developed first, accompanied by hydrothermal dolomitization of lime-

stone, and chloritization of the rhyolite. This was followed by argillic or clay mineral alteration and subsequent silicification. The productive stage was marked by the formation of hydromica and sericite.

Another area of interest from the standpoint of alteration study is the San Manuel district in Arizona. Here a large ore body was found during the war. The locality lies near the Mammoth mine where a copper stained area of only a few hundred square feet was exposed. Copper ores occur in the midst of a large altered area which has been studied in detail by Dr. G. M. Schwartz for the U. S. Geological Survey. According to a preliminary report a close relationship is indicated between the rock alteration and the primary sulfide mineralization. The effects of this alteration decrease outward from a center of greatest intensity. Several types of alteration have been recognized and a considerable number of clay minerals observed. The ore body appears to occupy a definite position in the pattern of hydrothermal alteration of the surrounding rocks.

In association with J. L. Kulp, C. M. Patterson and R. J. Wright and through the cooperation of several mining companies, the speaker has recently had an opportunity to study the relationship of alteration to ore deposition in the vicinity of Santa Rita, near Silver City, New Mexico.

The general geological relationships of the Santa Rita area are well known through the works of a number of excellent contributors. Topographic maps on a scale of 100 and 200 feet to the inch were furnished by the Kennecott Copper Corporation, the Empire Zinc Co., and the American Smelting and Refining Co. Many thousands of feet of diamond drill cores were available for inspection.

Field studies show that the alteration at Santa Rita followed the intrusive stock, was contemporaneous with some of the intrusive dikes and continued into later Tertiary time. Clay minerals are widely distributed through the various intrusive rocks of the district. They occur in dikes which accompany zinc ore bodies, in more or less horizontal intrusive sheets which are widely distributed, and in parts of a granodiorite porphyry intrusive. To date the relationship between the clay alteration and copper deposition is best understood. Certain of the alteration zones in the porphyry stock, correlate with reasonable accuracy with ore zones in the open pit copper mine at Santa Rita. This correlation has been of considerable interest and has provided stimulation to laboratory studies which are now in progress.

At Gilman, Colorado, the geological staff of the Empire Zinc Co., under the direction of Mr. S. E. Jerome, has been engaged for some time in the examination of the clay minerals and other alteration effects which occur in the Gilman porphyry. The bulk of this work has been carried on by Mr. Richard Bogue of the local staff. The Gilman porphyry

forms a sill some fifty feet thick which extends for a goodly number of miles laterally. In places zinc ore bodies have been found in the limestone below the sill. As a result of the alteration studies it seems clear that the clay minerals of the sill are hydrothermal in origin even under near surface conditions. In general, the intensity of alteration may be shown to be greatest in the vicinity of known ore bodies. In a mineral suite which comprises at least a dozen species, sericite, hydromica, kaolinite and dickite have been selected as furnishing the best index to the progress of alteration. These minerals are found in both the groundmass and the oligoclase phenocrysts of the porphyry, but most consistent results have been obtained where the progress of alteration has been interpreted from the destruction of the phenocrysts. The altered phenocrysts when studied statistically appear to indicate zones which in general are related to ore deposition. The Gilman studies although incomplete provide further confirmation of the significance of clay mineral alteration in connection with ore deposition.

The time has not arrived when one may correctly evaluate the implications of alteration studies. To date the results have more than justified the effort they have entailed and one may predict that the future will witness a much more intensive study of rock alteration than the past.

A most important aspect of these studies will be a closer coordination between field and laboratory than has previously existed. Although no one can foresee the ultimate outcome, it is clear that at least one better illuminated avenue has been found along which to approach the problem of replenishing mineral reserves. The same science of mineralogy which has yielded its scientific lore so generously in the years just past, bids fair to continue to do so.

REFERENCES

- LOVERING, T. S. (1941), The origin of the tungsten ores of Boulder County, Colorado: *Econ. Geol.*, **36**, no. 3, 229-279.
- MEYER, CHARLES (1946), Notes on the cutting and polishing of thin sections: *Econ. Geol.*, **41**, no. 2, 166-172.
- ROSS, C. S., AND SHANNON, E. V. (1926), The minerals of bentonite and related clays and their physical properties: *Am. Ceramic Soc. Jour.*, **9**, no. 2, 77-96.
- SALES, R. H. (1938), More intensive field studies for laboratory investigations of ore deposits: *Econ. Geol.*, **33**, no. 3, 239-250.
- SCHROTER, G. A., AND CAMPBELL, IAN (1940), Geological features of some deposits of bleaching clay: *Am. Inst. Min. Metall. Eng., Tech. Pub.* **1139**, 39 pages.
- SCHWARTZ, G. M. (1945), Geology of the San Manuel area, Pinal County, Arizona: *U. S. Geol. Survey, Strategic Minerals Investigations*, preliminary maps 3-180.

PRESENTATION OF THE SIXTH ROEBLING MEDAL OF
THE MINERALOGICAL SOCIETY OF AMERICA TO
CLARENCE SAMUEL ROSS

WALDEMAR T. SCHALLER, *Geological Survey, Washington, D. C.*

We have gathered together once again to honor one of our colleagues and to give tangible evidence of our appreciative evaluation of his outstanding mineralogic and petrologic accomplishments, by bestowing on him the Roebling Medal—the Washington Augustus Roebling gold Medal of the Mineralogical Society of America.

There is no need to tell you about the Medal, what it is and what it stands for. That story has been told to you in the course of previous presentations of the Medal. Rather, I shall tell you a little about the recipient, Dr. Ross, and touch lightly on some of his outstanding accomplishments in the fields of mineralogy and petrology. These have attained so wide a recognition that the bestowal of the honor which the Roebling Medal represents is eminently fitting as a token of appreciation of his meritorious achievements.

Dr. Clarence Samuel Ross is one of Professor W. S. Bayley's boys, receiving his doctorate from the University of Illinois in 1920. He joined the United States Geological Survey nearly thirty years ago and for the last quarter of a century has been Chief of the Section of Petrology in that Bureau.

Reading over his bibliography, his wide range of interests in matters geologic is shown by groups of papers on structural and areal geology, petrography and petrology, techniques developed and used in the microscopic studies of rocks and minerals, geologic processes, ore deposits, and, of course, mineralogy. Through nearly all his papers one senses his innate love of minerals, manifested even in papers not primarily mineralogic, for always geologic or petrologic problems were approached by means of detailed mineralogic studies. His very first paper is titled: "The 'chloritic' material in the ores of southeastern Missouri," which material, then unidentified, led to several investigations and reports on the mineral we call glauconite.

Naturally enough for a petrographer, much of his descriptive work has been on those minerals composing or closely related to rocks—petrologic minerals, if you wish. So we find papers on glauconite, the constituent of greensands; on iddingsite, an alteration of minerals of basalt; on montmorillonite, the constituent of the rock bentonite—the mineralogic descriptions tied in, wherever possible, with discussions of geologic relationships.

From a strictly mineralogic point of view, his greatest contribution probably has been in his exact quantitative determinations of the optical properties of minerals, for his own use in his researches, and to a much greater extent than is generally appreciated, for others, for he was always ready to place his time and abilities at the service of whoever called for help—ready and pleased to do much work and to make many determinations for others.

Along with this large quantity of actual determinations, many of which were never published, many of them serving to verify the determinations of others and hence submerged in a “general average,” is his remarkable ability to develop and apply special techniques for handling under the petrographic microscope very fine grained materials and other minerals difficult to orient for the exact determination of their optical properties.

Together with his general geological investigations, his work on the genesis and the paragenesis of the minerals involved—their geochemistry in fact—has resulted in his widely acclaimed Geological Survey publications (Prof. Paper 179) on the origin of the copper deposits of the Ducktown type in the southern Appalachian region, and (Prof. Paper 198) on the occurrence and origin of the titanium deposits of Nelson and Amherst Counties, Virginia. These two reports led inevitably to his chapter on Physical-chemical factors in the development of a deep-seated type of ore deposit, published in the Lindgren volume of the A.I.M.E.

His early work in the middle twenties on volcanic ash and its alteration to bentonite served to show the inadequateness of our knowledge of clay minerals and also served to introduce him to these clay minerals—a group which he then found was remarkable chiefly for the almost complete lack of sufficient and accurate data on their properties and relationships to one another and to other minerals. This state of ignorance was due essentially to the inherent difficulties of examining and handling such friable and fine grained materials and hence passed by on the part of most investigators. But not by him. The results he achieved, shown in part in his Geological Survey Professional Papers 165 “The Kaolin Minerals,” 185 “Halloysite and Allophane,” 205 “Minerals of the Montmorillonite Group,” have established so firmly his reputation as a clay specialist that “clay minerals” and “Dr. Ross” are considered synonymous.

The invitation he received to be the Edward Orton, Jr., Fellow Lecturer of the American Ceramic Society for 1945, an honor that but few have obtained, is but a further indication of the high regard in which he is held, both by his ceramic and by his geologic colleagues. In this address, Dr. Ross emphasized the common ground and the close relation-

ships between ceramics and geology and in particular that the ceramists have made greater use of mineralogic and petrographic techniques than those working in any other applied science.

Member of numerous scientific societies, he has served our Society as Councilor and as President and at home has served as President of the Geological Society of Washington. The two minerals rossite and meta-rossite have been named after him.

Dr. Clarence Samuel Ross, as the representative of the Mineralogical Society of America, I take great personal pleasure in presenting to you the Roebling Medal, awarded to you by our Society, in recognition of your meritorious achievements resulting from your outstanding investigations in the science of Mineralogy.

ACCEPTANCE OF THE ROEBLING MEDAL OF THE MINERALOGICAL SOCIETY OF AMERICA

CLARENCE S. ROSS, *U. S. Geological Survey, Washington, D. C.*

The Mineralogical Society of America bestows a very great honor when it calls one whose interest has been with minerals before its membership to receive the Roebling medal. Therefore, it is with sincere appreciation that I accept the Roebling medal of this Society from the hand of my friend and colleague, Waldemar T. Schaller. In casting over the names of those who have received this medal in the past there is a very deep sense of gratitude for all that it implies. Anything I can say will but inadequately express my heartfelt thanks, for there are times when spoken words are very ineffective, and this is such a time. There has also grown up the custom of an address by the recipient, perhaps to enforce a proper sense of humility. In response to this custom I have chosen to speak of some of the possible research problems in mineralogy, of some of the things yet to be learned. We also may consider how we can present mineralogic information known, or yet to be known, in a manner and with a completeness which will make it fully useful to mineralogists, geologists, and to the world. Even when the final volume of the new edition of Dana becomes available there will still remain fields of mineralogic information which will not have been covered, or which require fuller treatment.

The science of mineralogy is now blessed with effective methods of research and there is a very urgent need to fulfill the opportunities thus presented. These methods and techniques include the use of x -rays with their several modes of approach; the spectrograph, old in theory but now available with great refinement of equipment; perfected methods for differential thermal analysis; the improved methods for mineral separation; and the systematic determination of optical properties, particularly the more accurate determination of numerical values of indices of refraction. Of fundamental importance is the only partially developed study of paragenetic relationships. These methods were preceded by chemical analyses; measurement of crystal angles, studies of morphology; visual recognition, and mineral synthesis, an old but constantly developing method of study.

A survey of these various methods of mineralogic research indicates that the trained mineralogist of today should make use of analytical chemistry, of physical chemistry, of x -rays. He should be skilled in crystal optics, have a wide and intimate knowledge of the literature of mineralogy; be able to determine in the field the mode of occurrence and relationships of minerals; have a knack for the manipulation of the tools of



CLARENCE S. ROSS, RECIPIENT OF THE ROEBLING MEDAL
OF THE MINERALOGICAL SOCIETY OF AMERICA.

research and the design of new ones. Of course, few of us can hope to be all of these, but the research mineralogist must be skilled in several of these fields, and should know the applicability of all of them to problems in hand. Thus, almost the entire range of the physical sciences is placed at the disposal of the mineralogist. This means that mineralogy, like all the other sciences, must depend more and more upon the efforts of a group; but of necessity a group, the members of which can see the problem as a whole, and understand the roles that other lines of effort are to play. What is the range of the opportunities thus presented, and what are some of the most urgent problems that await attention?

Of all the methods of mineralogical research, the most neglected today is chemical analysis, the oldest of the truly rigorous methods. This is not said to belittle the others, *x*-rays, for instance, but because the others can not be effectively applied until more and better chemical analyses are available. Thus chemical analysis is, as since the beginnings of mineralogy, the foundation stone of mineral studies. How often do we see the use of old analyses, which may themselves be good, but whose correlation with the material under investigation is open to question, or which may have been made on impure materials? How often has the study of a mineral been handicapped because the mineralogist had to shop around to secure an accurate analysis? If this is true for single minerals it is all the more true where the study of mineral groups is involved. In a search of the literature for analyses of particular minerals one is commonly surprised to find how few are available, or that no recent analyses have been made.

Chemical analysis may become mere routine, but analytical work takes on new interest when the chemist learns to use petrographic or other methods of mineral research. He may thus come to feel that he is a full partner in a research group. These and other means must be provided to interest and recruit able chemists, so that analytical chemistry may play its fundamental role in mineralogic research.

Members of the Geological Survey and associates outside the Survey have recently been engaged in a canvass of the problems involved in a systematic study of the mica groups and this indicates that at least a hundred new analyses are needed for such a study. The newer methods, *x*-rays, spectrograph, or differential thermal analysis may often speedily identify a mineral and thus make a routine analysis unnecessary, but they do not remove the need for analysis as a part of a research program. New discoveries have a thrill for all of us, but enthusiasm for a new method too often leads to disregard of older but vital methods. The *x*-ray helps the chemist in the selection of materials, determinations of impurities, and even suggests procedures by indicating relationships. Likewise, the spectrograph has become so much a part of every well-

equipped laboratory that all rocks and minerals should be examined by this means before analysis. This will show the major elements which must be determined by chemical means and at the same time the minor ones present as traces, which may be determined better by spectrograph than by analysis. Differential thermal analysis may indicate the approximate proportions of gibbsite present in bauxites, and so the chemist will need to analyze only the high grade and more promising materials. These techniques are helpful supplements, but not substitutes for careful chemical analyses. By their means the chemist may be relieved of much routine work, and allowed to concentrate on the constructive research required if we are to understand mineral relationships and mineral groups.

The systematic study of mineral groups is probably the largest single line of research to which mineralogists may now devote their efforts. Important work along these lines is being done and within recent years we have come to have a far better knowledge of a number of mineral groups, but a large number of others await attack.

We may revert to the aforementioned mica group to illustrate some of the problems in the study of mineral groups; but in so doing there is no suggestion that they are uniquely important. Such a systematic study requires many additional analyses: in particular, of the various types of micas separated from igneous rocks. In general, the representation of rock-forming minerals is discouragingly small among available analyses. A systematic study of rock forming micas for instance will add not only to our knowledge of this mineral group, but also indicate much about the reciprocal relationships between the component minerals and the gross composition of the enclosing rock, and about paragenesis. Some of the more important minerals for which further study seems needful, are the amphiboles, the epidote group, the tourmalines, the hydrous magnesian silicates, including serpentine and all related materials, and many of the non-silicate mineral groups.

The separation of minerals for chemical analysis is one of the necessary, but most laborious duties connected with mineralogic research. It requires careful selection of suitable materials, patience, and ingenuity in the use of all available techniques for mineral separation—heavy solutions, the electromagnet; long hours of tedious hand picking; flotation; centrifuging, and at times special chemical treatment, involving knowledge of the chemical reactions which will leave the desired mineral unaffected. Routine treatments are rarely adequate, and each rock or mineral may present new problems. The suitability and purity of the separated material must be constantly controlled by petrographic study, x-ray, or spectrograph, and commonly by all of these methods.

The methods for determining optical properties under the petrographic microscope, particularly since the first appearance of Larsen's tables, has become so standardized and widely accepted that further advocacy of their usefulness is hardly needed among mineralogists. Optical properties however do not attain their greatest significance until they have been correlated with differences in chemical composition. Unfortunately, the optical methods have not been fully applied in some other branches of science which would be greatly benefited by the systematic use of the petrographic microscope, and the techniques which it makes possible.

The application of x -ray methods to the study of crystalline materials has been the greatest single contribution to mineralogy since the development of the polarizing microscope. A detailed discussion of the greatly refined techniques now available would be outside the limits of this address. However, a knowledge of the many ways by which x -rays may assist in mineralogic research should be familiar to all mineralogists. These include the identification of minerals, especially of fine grained aggregates and opaque minerals, the determination of mineral relations by means of similarities in their space lattice, and very exact determination of the lattice structure.

The study of the opaque minerals long lagged behind that of the other branches of mineralogy. These minerals presented unusual problems, since they were very difficult to identify by the older methods; mineral varieties were imperfectly known; analyses were at times correlated with the wrong mineral and mixtures had been unwittingly analyzed. Modern studies of the opaque minerals have applied x -rays, etch tests, microchemical techniques, hardness tests, color comparisons including spectrophotometry, polarized reflected light, and the spectrograph; as well as the older methods of chemical analysis, and crystallography. The electron microscope and in particular the replica film process will no doubt help in the understanding of these minerals. Research is being done on the greater refinement of all these methods, and polishing methods are being perfected. The significance of the physical relations of these minerals, and their paragenetic history are expanding subjects of investigation. All this intensive work is rapidly extending our knowledge of the opaque minerals, but much remains to be done.

The electron microscope has interested mineralogists as it has those in other branches of science. It has given us a knowledge of the physical habit of some of the minerals, which like the clay minerals, are capable of extreme dispersion, and hence, come within the range of its magnifications and its limited powers of penetration. Electron diffraction has supplemented x -ray diffraction and the use of the replica film process on polished surfaces has been mentioned.

The method of differential thermal analysis first devised by LeChâtelier, but recently reintroduced by Norton, has proved to be especially useful in studies of the clay minerals, bauxites, carbonates, and the hydrous magnesium silicates. In studies of minerals of the montmorillonite group, it even indicates whether the exchangeable base is sodium or calcium, and it has been especially useful in the preliminary evaluation of bauxite deposits.

The *Data of Geochemistry* compiled by Clarke went through many editions. Few books pertaining to any branch of the geologic sciences have ever had so wide an acceptance in Europe as well as in America, and about 46 thousand copies have been printed. More than 20 years have passed since the last edition appeared, but the need for some source of similar data has grown with the years, and the Geological Survey hopes to prepare such a revised and modern edition. The scope and practical limits of such a proposed new volume have not been fully determined. However we may briefly consider the various types of data which would be desirable in a fully monographic presentation of mineralogic information; perhaps constituting a more inclusive and voluminous series of publications than would be possible in even a greatly enlarged edition of the *Data of Geochemistry*.

One method of presentation might be by mineral groups, and an entire volume could easily be devoted to some of these. Obviously such a detailed presentation would need to be the joint product of a large group of specialists and would require years of preparation. The first parts might need revision by the time the later ones were finished, and so would represent continuing contributions. Doubtless all this can be only an objective for the time being, for during the war period the immediate need has been the chore of all of us, and a backlog of problems has accumulated, which must be cleared up before new projects are undertaken. Therefore the proposed outline is one of ideals, but ideals, even when not fully realizable, will help to orient our plans and activities. Ideals may eventually become realities. We must ever look forward, envisioning new projects, new plans, new expectations, for these are the very life breath of science.

If such a series of papers were to be realized, the chemical data should be very complete, and should return to the usage of Edward S. Dana in presenting an ample list of analyses of minerals, selected so far as possible to illustrate the different types, the various regions from which they have been reported, and the different genetic environments under which they are known to have formed. Rare elements, including those present only in traces, so far as these are known, should be listed, and their relation to environment and association should be discussed. The informa-

tion gained from mineral synthesis should be included, together with the phase relations. The different modes of formation as revealed by field relations should be presented, together with the indicated physical conditions, and the physical chemistry which favors the different modes of formation. The outstanding studies and regions where these modes of formation are best exemplified should be summarized. A list of the important minerals which commonly accompany each distinct genetic occurrence, and of the alteration products, would be an essential part of any such treatise. References to published studies along all these lines should be very exhaustive.

The part of the foregoing outline which would prove to be the most sketchy, and which would most forcibly present the magnitude of the mineralogic work yet to be done, would undoubtedly be that of genetic relations. It would, however, be the handbook for all those engaged in carrying forward studies of mineral paragenesis, and so be of immense help to all those interested in trying to discover how minerals form. This no doubt leads mineralogy far into the realm of geology, but some geologic problems must be attacked by a mineralogic approach, and both geology and mineralogy benefit thereby.

The lines of research here suggested may not all be of the best; certainly some of you will favor others; and avenues will no doubt open before us which none can foresee. However, all will agree that we have awaiting us problems, opportunities, duties, for all of which we can be immensely thankful. Mineralogy is among the very oldest of the sciences, but it still is young, for it grows and hopes and plans. Colonel Roebling, in whose honor this medal was named, indicated his faith in the future of mineralogy through his generous endowment of our Society, and we, being endowed with so great an opportunity, can help to justify his faith.

This medal is a very beautiful thing in itself, but to me its greatest values will be its symbolism of the science we all love and serve and as a reminder of the heartfelt gratitude I owe to the Mineralogical Society, and to you, my many friends, who are its representatives here today.

MEMORIAL OF GERALD FRANCIS LOUGHLIN

WILBUR S. BURBANK, *U. S. Geological Survey, Washington, D. C.*

Gerald Francis Loughlin, former Chief Geologist of the United States Geological Survey, passed away in the evening of October 22, 1946, a little over two years from the time that he had relinquished his administrative duties in order to devote himself to research. After more than 25 years of unselfish devotion to administrative services he had looked forward to continuing some of his earlier research activities and to working in new fields. His death, from a heart attack, came as an unexpected shock to his friends as well as to his immediate family, for he had suffered no serious illness, although he had been slightly indisposed a week or so prior to his death from what appeared to be a minor ailment. His greatly increased responsibilities in the last few years of service as Chief Geologist during the war had been a considerable strain and one from which he had not fully recovered his normal vigor.

Loughlin was born in Hyde Park, Massachusetts, December 11, 1880, the son of John Francis Loughlin and Adelia (Lane) Loughlin. After seven years of training in the Boston Latin School he entered the Massachusetts Institute of Technology in 1899 and received the degree of Bachelor of Science in geology in 1903. As an undergraduate at "Tech" his interest in geology was first aroused by Professor W. O. Crosby, with whom he spent his earliest days in the field and with whom he collaborated on his first publication. Shortly after his graduation he worked as a field assistant with the United States Geological Survey and the Connecticut Geological Survey under Dr. Herbert E. Gregory, studying the clays and clay industry of that State. He then entered the Yale Graduate School under a teaching fellowship, and there he received his doctorate in 1906. His graduate work, which was carried on under Gregory, Pirsson, and Barrell, dealt with problems of igneous and metamorphic geology in Connecticut and adjacent States, and in the period before his death he turned again to these early interests; he began to prepare a review of certain phases of the metamorphic geology of New England, and to aid in the preparation of a new geologic map of Connecticut.

In 1906 Loughlin returned to Boston, and he held an instructorship in geology at the Massachusetts Institute of Technology until 1912. Beginning in 1910, he also served summers as Junior Geologist with the United States Geological Survey, first with Frank C. Calkins in Idaho and later with Waldemar Lindgren at Tintic, Utah. Partly through the interest of these men in his work he decided to become permanently associated with the Geological Survey and went to Washington, D. C.,



GERALD FRANCIS LOUGHLIN
1880-1946

in 1912. His field work carried him again into the west, where under B. S. Butler and his associates he contributed to the comprehensive study of the mining districts of Utah then under way. In 1913 he also made a special mineralogic and structural study of newly developed oxidized zinc ores of the Leadville district, Colorado, and later the same year reviewed the field work in this district with J. D. Irving, who was then working on the uncompleted manuscript of the report on Leadville started by S. F. Emmons before his death. A few years later Irving entered into war service in France, where he died in 1918, and the entire task of completing the Leadville Professional Paper then fell to Loughlin.

In the meantime, when he returned to Washington after the 1913 season, he had assumed the subjects of building stones and cements for the annual volumes on Mineral Resources, then prepared by the Geological Survey. In this commodity work he brought to bear his characteristic thoroughness and analytical approach, and he soon won recognition for his investigative contributions in the mineral industry as well as in the field of scientific geology. Within a few years, however, his research work in economic geology became increasingly interrupted by administrative duties, for in 1917 he was appointed Chief of the non-metals section of the Division of Mineral Resources, and in 1918 was in charge of the section of metal resources as well as of stone and lime investigations. In 1920 he assumed charge of the entire division of Mineral Resources including its western offices, a position which he held until 1924, when the activities of this division were transferred to the Bureau of Mines. During his service with this division he contributed many chapters to the annual reviews of mineral resources, and made a number of special investigations of building stone that won him national recognition as an authority on this subject.

Dr. Loughlin served from 1924 to 1935 as Geologist in Charge of the Section of Metalliferous Geology, and from 1935 to 1944 as Chief Geologist of the Geological Survey. From 1944 until his death, he served as Special Scientist, and as a staff geologist, advisory to the Director and to the Chief Geologist. During the years of administrative service he managed to continue his investigations of mining districts and of special geologic subjects, completing the widely known Professional Paper on the Leadville mining district in 1925 and initiating a study of deep-level mining activities in the Cripple Creek district of Colorado. He always kept in close touch with a broad field of economic geology and contributed papers in petrology, ground water, economics of minerals, and other special subjects, besides his larger publications that are internationally recognized as important contributions to economic geology.

He was a research man at heart, but he possessed that combination

of qualities desirable for effective administration of scientific work. Guided by his own urge in scientific pursuit, he was always sympathetically appreciative of the work and aspirations of others and ever willing to devote much time to helpful advice and criticism. Being of the older administrative school, he was not given to easy familiarity in his everyday professional contacts, but at his ease and through other informal associations he displayed an ever present fund of humor and enjoyment of comradeship. One of his favorite forms of relaxation was in music. Before and during his college years he had become proficient enough with a flute to engage in amateur and even in professional orchestral work, and he also sang and played the piano. He was also active in college musical shows and composed music as well as verse for several of them. This enjoyment of music and of light satire inspired him to take part in many shows of the Pick and Hammer Club of the Geological Survey where the foibles of the organization, administrative or geologic, were annually ridiculed. He contributed to the musical scores and jibes at these performances and could never resist an invitation to train and lead the choral activities of the vocally inclined geologists.

Dr. Loughlin was a member of many national scientific and engineering societies, in several of which he served on administrative committees or held positions of honor. He was President of the Society of Economic Geologists in 1940 and of the Geological Society of Washington in 1923, and had served as Councilor and in other capacities with the Geological Society of America. He was also a member of the American Institute of Mining and Metallurgical Engineers, the American Association of Petroleum Geologists, the American Geophysical Union, and of the Washington Academy of Sciences, and a Fellow of the Mineralogical Society of America and of the American Association for the Advancement of Science. He was a prominent and active member of the All Souls Unitarian Church of Washington, D. C., and belonged to the Cosmos Club in that city. He was a member of the Society of Sigma Xi.

When Dr. Loughlin returned to Boston in 1906 he married Grace Elizabeth French of Boston, Massachusetts, who with their daughter, Mrs. Wilbur S. Burbank, and two grandchildren, all of Washington, D. C., survive him.

BIBLIOGRAPHY

- A descriptive catalogue of the building stones of Boston and vicinity (Mass.) (with Prof. W. O. Crosby): *Tech. Quarterly*, **17**, 165-185 (1904).
The clays and clay industries of Connecticut: *Conn. Geol. and Nat. Hist. Survey*, Bull. No. **4**, 121 pp., 13 pls. (1905).
Recent literature on economic geology (with others): *Econ. Geology*, vol. **2**, No. 1 (1907) to vol. **7**, No. 1 (1912).

- Ore deposition at Aspen, Colorado: *Econ. Geology*, **4**, No. 7, 658–660 (1909). (Discussion of paper by J. E. Spurr).
- The Norwood meteorite (?): *Science*, new ser., **31**, pp. 418–419, March 18, 1910. (Describes petrographic characters of the stone, the meteoric origin of which is doubted. Discussion of paper by Prof. Frank Very.)
- Intrusive granites and associated metamorphic sediments in southwestern Rhode Island: *Am. Jour. Sci.*, 4th ser., **29**, 447–457, 2 fig. (May 1910). (Shows granites previously regarded as pre-Cambrian to be intrusive into Carboniferous strata.)
- The lithology of Connecticut (with Prof. J. Barrell): *Conn. State Geol. and Nat. Hist. Survey*, Bull. **13**, 207 pp., 6 tables (1910). (Loughlin's part gives descriptions of the Connecticut educational series of rocks.)
- Contributions to the geology of the Boston and Norfolk basins, Massachusetts; the structural relations between the Quincy granite and the adjacent sedimentary formations: *Am. Jour. Sci.*, 4th ser., **32**, 17–32, 4 figs., (July 1911).
- Tables for determination of minerals in rock specimens. Published by Mass. Inst. Technology for use in elementary classes.
- The gabbros and associated rocks at Preston, Conn.: *U. S. Geol. Survey*, Bull. **492**, 158 pp., 14 pls., 18 figs. (1912).
- Reconnaissance in the southern Wasatch Mountains, Utah: *Jour. Geology*, **21**, No. 5, 436–452, 4 figs. (1913). (Abst.) *Jour. Wash. Acad. Sciences*, **3**, 50–51 (1913).
- A reconnaissance in the Canyon Range, west-central Utah: *U. S. Geol. Survey*, Prof. Paper **90**, 51–60, 1 pl., 5 fig. (1914). (Abst.) *Jour. Wash. Acad. Sciences*, **5**, 19 (1915).
- The oxidized zinc ores of the Tintic district, Utah: *Econ. Geology*, **9**, No. 1, 1–19, 2 pls., 8 figs. (Jan. 1914).
- An unconformity in the Narragansett Basin of Rhode Island and Massachusetts (with L. A. Hechinger): *Am. Jour. Sci.*, 4th ser., **38**, 45–64, 1 fig. (map) (July 1914).
- Recent alunite developments near Marysville and Beaver, Utah: *U. S. Geol. Survey*, Bull. **620**, 237–270 (1915).
- Stratigraphy of the Tintic mining district, Utah: (Abst.) *Jour. Wash. Acad. Sci.*, **5**, 142 (1915).
- A reconnaissance of the Cottonwood-American Fork mining region, Utah (with B. S. Butler): *U. S. Geol. Survey*, Bull. **620**, 165–226 (1915).
- Wolframite and scheelite at Leadville, Colorado (with R. S. Fitch): *Econ. Geology*, **2**, No. 11, 30–36 (Jan., 1916); *Min. World*, **44**, 1039–1040 (1916).
- Magnesia in limestone, 11 pp. *National Lime Manufacturers' Association*, Bull. No. **4**, 11 pp. (1916).
- Ores, magmatic emanations and modes of igneous intrusion (Discussion of papers by B. S. Butler and R. A. Daly): *Econ. Geol.*, **11**, 284–288 (1916).
- Faulting in Tintic mining district, Utah: (Abs.) *Jour. Wash. Acad. Sci.*, **6**, 190 (1916).
- Crandallite, a new mineral (Tintic mining district, Utah) (with W. T. Schaller): *Am. Jour. Sci.*, 4th ser. **43**, 69–74 (1917).
- Limestone and Lime (a chapter in *U. S. Geol. Survey*, Bulletin **666**, entitled "Our Mineral Supplies"): *U. S. Geol. Survey*, Bull. **666**, 107–112 (1917).
- Zinc carbonate and related copper carbonate ores at Ophir, Utah: *U. S. Geol. Survey*, Bull. **690**, 1–14 (1917).
- Two lamprophyre dikes near Santaquin and Mount Nebo, Utah: *U. S. Geol. Survey*, Prof. Paper **120**, 101–109 (1918).
- The oxidized zinc ores of Leadville, Colorado: *U. S. Geol. Survey*, Bull. **681**, 91 pp. (1918).
- Geology and ore deposits of the Tintic district, Utah (with Waldemar Lindgren): *U. S.*

- Geol. Survey*, Prof. Paper **107**, 282 pp., 39 pls., 49 figs., 1919. (Part 1. pp. 15-104, by Loughlin).
- Other Industrial Minerals, a chapter in the book entitled, *The Strategy of Minerals*, G. O. Smith, editor. New York, D. Appleton and Company (1919).
- Rock products and the war. (Abst.) *Bull. Geol. Soc. Am.*, **30**, 97 (March 31, 1919).
- The ore deposits of Utah (with B. S. Butler and others): *U. S. Geol. Survey*, Prof. Paper **111**, 672 pp., 74 figs., 57 pls. (incl. maps), 1920.
- Limestones and marls of North Carolina (with E. W. Berry, and J. A. Cushman): *North Carolina Geol. and Econ. Survey*, Bull. **28**, 211 pp., 3 figs., 17 pls. (incl. maps), 1921.
- Needed: Complete and reliable analyses of limestones. Progress in the industry requires greater knowledge of the impurities found in limestones. Their kind, form and effect. *Rock Products*, pp. 2-24 (Sept. 10, 1921).
- Arsenic—Demand and supply: *Oil, Paint and Drug Reporter*, p. 31 (March 29, 1923).
- An interesting case of dangerous aggregate; the altered feldspar and causes of its disintegration: *Proc. Am. Concrete Inst.*, **19**, 150-153 (1923).
- Notes on ground waters: *Econ. Geology*, **19**, No. 1, pp. 62-71, 2 figs. (January-February, 1924).
- Arsenic deposits in the United States (with V. C. Heikes): *U. S. 68th Cong., 1st Sess.*, Sen. Doc. No. **27**, 7 pp. (1924).
- Guides to ore in the Leadville district, Colorado: *U. S. Geol. Survey*, Bull. **779**, 37 pp., 4 figs., 7 pls. (incl. map), 1926.
- Geology and ore deposits of the Leadville mining district, Colorado (with S. F. Emmons, J. D. Irving): *U. S. Geol. Survey*, Prof. Paper **148**, vol. 16, 368 pp., 70 pls., 111 figs. (1927).
- The weathering and seasoning of stone, Parts I and II: *Stone*, **44**, pp. 633-634, 697-698 (1923). Parts III and IV, *Stone*, **45**, pp. 31-33, 95 (1924).
- Qualifications of different kinds of natural stone for concrete aggregate: *Proc. Am. Concrete Inst.*, **23**, 319-351, 19 figs. (1927).
- Ore at deep levels in the Cripple Creek district, Colorado: *Am. Inst. Mining Eng.*, **75**, 42-73, 12 figs. (1927).
- Discussion on research in processes of ore deposition: *Am. Inst. Mining Eng.*, **76**, p. 304 (1928).
- Usefulness of petrology in the selection of limestone: *Rock Products*, **31**, No. 6, 50-59 (March 17, 1928).
- Indiana oolitic limestone. Relation of its natural features to its commercial grading: *U. S. Geol. Survey*, Bull. **811**, 113-202, 10 figs., 19 pls. (1929).
- Indiana oolitic limestone: *Mining & Metallurgy*, **10**, No. 266, pp. 65-66, 4 figs. (February 1929).
- Gold reserves of the United States (with H. G. Ferguson and others): Gold resources of the World, pp. 389-414, 2 figs., tables. *Internat. Geol. Cong.*, Pretoria, S. Africa (1930).
- Geology of Leadville and vicinity, a review of old and recent studies: (Abst.) *Jour. Wash. Acad. Sci.*, **21**, No. 15, 370 (Sept. 19, 1931).
- The results of recent geologic work at Cripple Creek, Colorado: (Abst.) *Jour. Wash. Acad. Sci.*, **22**, no. 14, 416-417 (August 19, 1932).
- Precious metal supplies and the price level: Chapter in *Mineral Economics* (F. G. Tryon and E. C. Eckel, editors); lectures, Brookings Institution; New York, McGraw-Hill Book Co. (1932).
- Leadville mining district (with C. H. Behre, jr.): *XVI Internat. Geol. Cong.*, Guidebook **19**, Colorado, Excursion C-1, pp. 77-91 (1932).
- Cripple Creek mining district: *XVI Internat. Geol. Cong.*, Guidebook **19**, Colorado, Excursion C-1 (1932), pp. 113-122.

- Classification of ore deposits (with C. H. Behre, jr.): Ore Deposits of the Western States (Lindgren Volume), *A.I.M.M.E.*, 17-55 (1933).
- Further remarks on the Cripple Creek volcano, Colorado: Talk before meeting of Am. Geophys. Union; abst. in *Proc. Am. Geophys. Union*, 1933. 13th Ann. Rept., p. 243, *Nat. Research Council* (1933).
- Zoning of ore deposits in and adjoining the Leadville district, Colorado (with C. H. Behre, Jr.): *Econ. Geology*, 29, No. 3, 215-254, 1934.
- Dissected pediments in the Magdalena district, New Mexico (with A. H. Koschmann): *Bull. Geol. Soc. Am.*, 45, no. 3, 463-477, 1934.
- The United States Geological Survey's point of view on relations between Surveys and the mining industry (with others): *Trans. Am. Inst. Min. Met. Eng.*, 115, *Mining Geology*, pp. 407-414 (1935).
- Geology and ore deposits of the Cripple Creek district, Colorado (with A. H. Koschmann): *Proc. Colo. Sci. Soc.* 13, no. 6, 217-435 (1935).
- Cripple Creek today: *Eng. and Min. Jour.*, 136, no. 8, 372-377, August 1935 (Colorado number).
- Lead and zinc resources of western United States (with E. T. McKnight): *Proc. 5th Pacific Sci. Cong. Canada* 1933, pp. 1401-1424, 3 figs., map (1934).
- Relations of structure to surface features in the Pikes Peak quadrangle, Colo.: *Jour. Washington Acad. Sci.*, 25, no. 12, 573-574 (1935).
- Zoning in certain mining districts in the Mosquito and San Juan Mountains, Colorado (with others): *16th Internat. Geol. Cong.* 1933, Rept. vol. 1, pp. 433-446 (1936).
- The origin of lamprophyres: (Abst.) *Trans. Am. Geophys. Union*, 17th Ann. Mtg. Pt. 1, p. 235, *Nat. Research Council* (1938).
- Paragenetic study of hypogene gold and silver telluride ores of Cripple Creek, Colo. (with others): (Résumé of communications made to the *XVIIth Int. Geol. Congress*, Moscow, 1937); *Pan-Am. Geologist*, 74, no. 1, 36-37 (1940).
- Comments on the origin and major structural control of igneous rocks and related mineral deposits: *Econ. Geology*, 36, no. 7, 671-697 (1941); Spanish transl. by Jorge Muñoz C. in *Bol. Minero Soc. Nac. Minería* (Chile), Ano 58, no. 504, 348-351 (1942).
- Geology and ore deposits of the Magdalena Mining district, New Mexico (with A. H. Koschmann): *U. S. Geol. Surv.*, Prof. Paper 200, 168 pp., 38 pls., 28 figs. (1942).
- Explorations for Mineral Reserves (address delivered before the Colorado Mining Association and Amer. Mng. Congress, 1944): *Mining Congress Jour.*, 30, no. 7, 18-21 (July 1944).
- Chapters in *U. S. Geol. Survey Mineral Resources of the United States*, 1913 to 1925, as follows:
- Stone industry: 1913, pt. 2, pp. 1346-1366, 1376-1387, 1914; 1914, pt. 2, pp. 819-891, 1915; 1915, pt. 2, pp. 761-842, 1916; 1916, pt. 2, pp. 993-1078, 1918.
- The gypsum industry in 1914: pt. 2, pp. 261-270, 1915.
- The production of sand and gravel in 1914: pt. 2, pp. 271-283, 1915.
- The production of lime: 1914, pt. 2, pp. 363-373; 1915, pt. 2, pp. 245-264; 1916 pt. 2, pp. 433-462, 1918.
- Slate: 1915, pt. 2, pp. 19-31; 1916, pt. 2, pp. 61-72; 1917, pt. 2, pp. 121-138, 1916-1918.
- Lime in 1917: pt. 2, pp. 583-613, May 13, 1919.
- (with Coons, A. T.). Stone in 1917: 1917, pt. 2, pp. 615-682, June 20, 1919.
- (with Coons, A. T.). Slate in 1918: 1918, pt. 2, pp. 267-282, 1 fig., October 23, 1919.
- (with Insley, Herbert). Lime in 1918: 1918, pt. 2, pp. 815-856, 3 figs., 3 pls., June 7, 1920.
- (with Coons, A. T.). Stone in 1918: 1918, pt. 2, pp. 1189-1313, 8 figs., 7 pls., October 11, 1920.

- (with Coons, A. T.). Slate in 1919: 1919, pt. 2, pp. 369-375, July 29, 1921.
- (with Coons, A. T.). Lime in 1919: 1919, pt. 2, pp. 405-418, October 6, 1921.
- (with Coons, A. T.). Stone in 1919: 1919, pt. 2, pp. 419-455, October 18, 1921.
- (with Coons, A. T.). Slate in 1920: 1920, pt. 2, pp. 135-143, October 12, 1921.
- (with Coons, A. T.). Lime in 1920: 1920, pt. 2, pp. 177-188, November 3, 1921.
- (with Coons, A. T.). Stone in 1920: 1920, pt. 2, pp. 225-262, March 6, 1922.
- Magnesium in 1921: 1921, pt. 1, pp. 19-20, June 14, 1922.
- (with Coons, A. T.). Slate in 1921: 1921, pt. 2, pp. 23-30, June 29, 1922.
- (with Coons, A. T.). Lime in 1921: 1921, pt. 2, pp. 155-168, November 29, 1922.
- (with Coons, A. T.). Stone in 1921: 1921, pt. 2, pp. 175-213, January 22, 1923.
- (with Clark, Martha B.). Mineral resources of the United States in 1922 (preliminary summary): 1922, pp. 1*a*-124*a*, August 15, 1923.
- (with Coons, A. T.). Lime in 1922: 1922 pt. 2, pp. 195-206, 1923.
- (with Coons, A. T.). Slate in 1922: pt. 2, pp. 165-175, November 6, 1923.
- (with Coons, A. T.). Stone in 1922: 1922, pt. 2, pp. 261-344, 3 figs., April 10, 1924.
- (with Coons, A. T.). Slate in 1923: 1923, pt. 2, pp. 49-61, 3 figs., September 25, 1924.
- (with Coons, A. T.). Stone in 1923: 1923, pt. 2, pp. 205-234, December 18, 1924.
- (with Coons, A. T.). Lime in 1923: 1923, pt. 2, pp. 275-284, December 19, 1924.
- (with Coons, A. T.). Slate in 1924: U. S., Bur. Mines, Mineral Resources U. S., 1924, pt. 2, pp. 151-160, December 16, 1925.
- (with Coons, A. T.). Lime in 1924: U. S., Bur. Mines, Mineral Resources U. S., 1924, pt. 2, pp. 193-230, May 22, 1926.

MEMORIAL OF VLADIMIR IVANOVICH VERNADSKY

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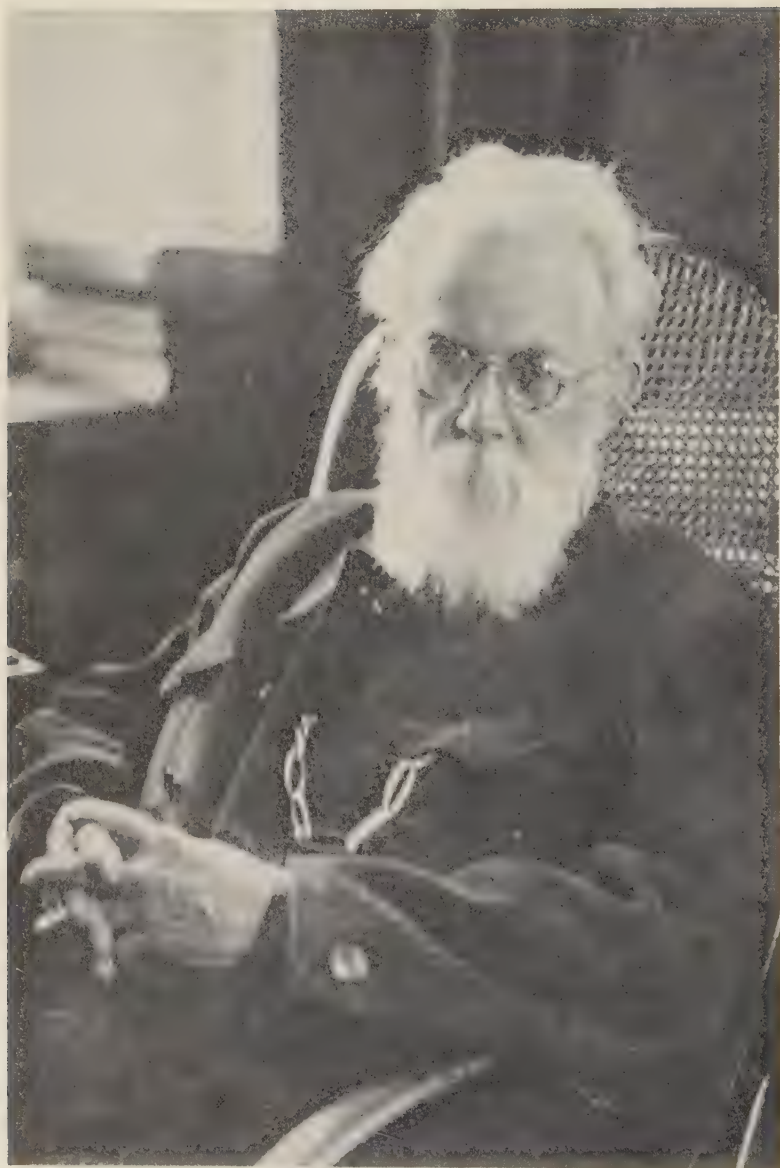
Vladimir Ivanovich Vernadsky died in Moscow on January 6, 1945, after a brief illness, only a few months before the death of his most illustrious pupil, A. E. Fersman. Born in St. Petersburg on March 12, 1863, Vernadsky studied at the University of St. Petersburg, taking chemistry under Mendeléeff and Menshutkin, geology under Inostrantsev, and mineralogy under Dokuchaev, the founder of the Russian School of Pedology (Soil Science). The latter, especially, greatly influenced Vernadsky, whose first publication "Description of geology and soils of a district in Poltava Province" was prepared under Dokuchaev's direction.

After graduation he was sent abroad in preparation for a professorship and continued his studies of chemistry with LeChatelier and mineralogy with Fouqué in Paris, and Groth, Sohnke and Haushofer in Germany.

His Master's thesis, (Moscow, 1891), was based on a study of the silimanite group. The novel conclusions on the role of alumina led him to develop a theory on the structure of silicates which, 36 years later, was confirmed by Bragg on the basis of *x*-ray analyses. His Doctorate thesis (1896) on "Phenomena of gliding in crystalline substance" introduced physical interpretations in the study of crystals.

During the twenty years of his professorship in Moscow University (1891-1911) he worked in the fields of mineralogy and crystallography and built up one of the best equipped laboratories in the world, and above all taught hundreds of students, many of whom now are outstanding workers in the fields of mineralogy, geochemistry, and other allied sciences. He made many field trips to the Urals, Crimea, Caucasus, and Fergana. In teaching mineralogy he developed a new approach to minerals which he treated not as rigid entities, but as products of a definite stage of chemical processes in the earth's crust. In 1908, he begun to publish his "Essay of descriptive mineralogy." To prepare this monograph he examined all the large mineral collections of Europe, the United States, and Canada, and studied the voluminous literature in many libraries at home and abroad. This work remains incomplete, it covers only native elements, and sulphide and selenide compounds.

In 1911 Vernadsky resigned from Moscow University in protest against the reactionary policies of the Minister of Education. The Academy of Sciences in St. Petersburg, to which he was elected in 1906, became his home and his later work and life for the most part were concentrated in that Institution.



VLADIMIR IVANOVICH VERNADSKY
1863-1945

During World War I he devoted all his time to the study of radioactivity and to the organization of expeditions to Lake Baikal and Transbaikalia in search of radioactive minerals and rocks. He realized in 1915 that insufficient information was available with regard to strategic minerals and gave much of his time to the organization of a Committee for the "Study of Natural Productive Forces," commonly known as "KEPS," to which he attracted not only members of the staff of the Academy of Sciences but also geologists from the Geological Committee, Department of Mines, professors and their students.

In 1917, he became afflicted with tuberculosis and left Petrograd, first for Poltava and later for Yalta. In 1918 he became the first President of the Ukrainian Academy of Science which he helped to organize and was Rector of Taurida University (1920). In 1921, when the White Armies were defeated, he left Russia and lived in France for five years. During his life in Paris he gave a seminar course on Geochemistry at the Sorbonne.

His intense patriotism forced him to return to Russia in 1926. Although in his 64th year he worked with renewed interest and was instrumental in the creation of many vital committees of the Academy of Sciences. Thus, he organized the "Committee for the Study of Meteorites" of which he was chairman, and the "Committee on the Study of Frozen Ground," the importance of which was soon realized and which became an Institute of Merzlotovedenie. The practical importance of these studies was brought to the attention of U. S. Army engineers and geologists during the construction of the Alcan Highway and military airfields and bases in Alaska in World War II. Their experience with frozen ground ("permafrost") aroused interest in the intensive Russian literature and led to the establishment of a program of field and laboratory studies.

His interest in radioactivity, which began after he heard Joly at the International Congress in Dublin in 1908, continued all his life. He organized surveys for systematic prospecting for radioactive rocks and minerals, surface and ground waters, and oil brines, but he was particularly interested in the role of radioactive elements in geology and their distribution in the earth's crust.

Vernadsky was one of the first to see clearly in advance the need for specialized studies and he possessed great ability to persuade others of the need for undertaking such studies, as shown in his organization of various committees. In June of 1940 he urged the Academy of Sciences to undertake the study of uranium minerals in connection with the problem of atomic energy and by July 25th such a committee had been organized.

An examination of his selected bibliography¹ shows the great variety of subjects which interested him. Fersman, one of his most brilliant and devoted pupils, gives² an interesting tabulation of Vernadsky's papers, by subject, as follows:

| | |
|-----------------------------|-------|
| Mineralogy | 30% |
| Biogeochemistry | 17% |
| Geochemistry | 16% |
| Radioactivity | 12% |
| General scientific problems | 12% |
| Crystallography | 7% |
| Soils | 3% |
| Strategic minerals | 3% |
| | <hr/> |
| | 100% |

In summing up his activities, we see that Vernadsky worked in mineralogy, crystallography, geochemistry, biogeochemistry, and radioactivity, and was interested in the history of Natural Science. Each of these presents a large field of human knowledge. In some he was a pioneer (biogeochemistry, geochemistry), in others he made valuable contributions through his creative thought and scientific work. In mineralogy he introduced new approaches and helped to develop it as a science of the chemistry and history of the earth's crust.

His last years were saddened by the horrors of German invasion, and the loss of his wife, his constant and helpful companion. Yet, to the last he maintained his deep interest in science and in the future of mankind.

In his own country he was early recognized as an outstanding scientist. In 1928 he was elected a Correspondent Member to the Mineralogical Section of the French Academy.

To all who knew him, even slightly, he will remain an ideal of a man of high purity and beauty of character and a scientist who never lost his interest in the search for knowledge.

SELECTED BIBLIOGRAPHY

- On phosphorites of Smolensk Province: *Tr. Volno-Ekon Obsch.*, No. 11, 263-293 (1888).
 Note sur l'influence de la haute température sur le disthène: *Bull. soc. franc. minéral.*, **12**, 447-456 (1889).
 Ein Beitrag zur Kenntniss des hexagonalen Krystallsystems: *Zeits. Kryst.*, **15**, 473-486 (1889).
 Sur la reproduction de la sillimanite: *Bull. soc. franc. minéral.*, **13**, 256-371 (1890).

¹ In preparing his selected bibliography I tried to list all his important papers on mineralogy, especially those which were translated into French, German, or English.

² Fersman, A. E., V. I. Vernadsky, *Bull. Soc. Nat. Moscow*, Ser. Geol., **21**, No. 1, 53-63 (1946).

- Sur la reproduction de la sillimanite et la composition minéralogique de la porcelaine: *C. R.*, **110**, 1377–1380 (1890).
- Sillimanite group and the role of alumina in silicates: *Bull. Soc. Nat., Moscow*, **5**, 100 pp.; French summary, 165–169 (1891).
- On polymorphism as a general property of matter: *Sc. notes Moscow Univ.*, Dept. Nat. Sci., **9**, 1–18 (1892).
- Lectures on crystallography: *Student's publication*, 1–285, Moscow (1894).
- Chemical composition and crystalline forms of the most important minerals: Appendix to lectures on crystallography, 1–22, Moscow (1894).
- On causes of some anomalies in crystals: *Bull. Soc. Nat., Moscow*, **10**, 21–22 (1896).
- Phenomena of gliding in crystalline substance: *Sci. Notes Mosc. Univ.*, Dept. Nat. Sci., **13**, III+182 pp., 2 tables (1897).
- Lectures on descriptive mineralogy: Vol. **1**, pp. 288, Moscow (1899).
- On turingite and stilpnomelane of Russian deposits: *Bull. Soc. Nat., Moscow*, **14**, 41–45 (1900).
- Zur Theorie der Silikate: *Zeits. Kryst.*, **34**, 34–66 (1901).
- On crystals of α -sulphur and its Russian deposits: *Bull. Soc. Nat., Moscow*, **16**, 479–501 (French summary) (1902).
- On apatites from Horanta-Hoh in Caucasus: *Bull. Soc. Nat., Moscow*, **16**, 502–506 (French summary) (1902).
- With S. Popoff. Ueber den Boraxgehalt von Eruptionsproducten aus dem Salzgebiet von Kertsch und Taman: *Zeits. prakt. Geol.*, **3**, 79–81 (1902).
- Fundamentals of crystallography. Part 1. Introduction. Study of symmetry. The phenomena expressed by the law of polygones. Part 1. *Sci. Notes Moscow Univ.*, Dept. Nat. Sci., **19**, VIII+344 pp. (1903).
- With S. Popoff. Zur Paragenese des Goldes von Siebenbürgen: *Cbl. Min.*, 331–332 (1903).
- Phase rule application to crystallography: *Bull. Soc. Nat., Moscow*, **18**, Nos. 1–3, 8–15 (1904).
- Häuy's law and vectorial structure of crystals: *Tr. Dept. of Phys. Sci. Soc. of Nat.*, **12**, Fasc. 1, 1–14, Moscow (1904).
- Course of Mineralogy and Crystallography for Medical Students. Pp. 1–134, Moscow (1906).
- On striation of crystalline faces: *Proc. Acad. Sci.*, **1**, 289–317 (1907).
- Physical theory of twin crystals: *Ibid.*, **1**, 335–352 (1907).
- Vorobyevite and chemical composition of beryls: *Tr. Geo. Mus. Acad. Sci.*, **2**, fasc. 5, 81–102 (1908).
- On crystal energy: I. On crystallization of matter in the presence of a ready crystal: *Proc. Acad. Sci.*, **2**, 215–229 (1908). II. On simultaneous crystallization of two immiscible bodies: 245–256 (1908).
- Essay on descriptive mineralogy. Native elements, vol. **1**, fasc. 1, *Publ. Acad. Sci.*, 1–176, St. Petersburg (1908). *Ibid.* fasc. **2**, 177–336 (1909); fasc. **3**, 337–496 (1910); fasc. **4**, 497–656 (1912); fasc. **5**, 657–839 (1914).
- Beiträge zur Energetik der Krystalle: *Zeits. Kryst.*, **45**, 124–142 (1908).
- On vacancies in isomorphic mixtures: *Proc. Ac. Sci.*, **3**, 139–149 (1909).
- On isomorphism of the alumo- and ferri-silicate group: *Ibid.*, 1183–1902 (1909).
- Notes on distribution of chemical elements in the earth's crust. I. History of rubidium, cesium, and thallium. II. Distribution of thallium in the earth's crust: *Proc. Acad. Sci.*, 820–832 (1909). III. Observations, 1909–1910, pp. 1129–1148 (1910). IV. Distribution of indium: 187–193 (1911). V. Observation of 1910, pp. 1107–1018, 1911, Vol. **8**, 951–966 (1914). IV. Distribution of indium: **10**, 1323–1343 (1916).

- Titanium in soils: *Pedology*, **2**, No. 3, 255-259 (1910).
- Paragenesis of chemical elements in the earth's crust. Jour. 12th Conference Russ., *Naturalists and Physicians*, 73-91 (1910).
- Application of LeChatelier-Gibbs law to phenomena of crystallization: *Ibid.* (Abstract), p. 484 (1910).
- Need for investigation of radioactive minerals of the Russian Empire: *Publ. Acad. Sci.*, 1-54, St. Petersburg (1910).
- Comments on Lomonosov's work in mineralogy and geology. Lomonosov's contributions in the field of Natural Sciences: *Publ. Acad. Sci.*, 141-240 (1911).
- Discovery of crocoite, Lomonosov's collection: *Publ. Acad. Sci.*, 345-354 (1911).
- Together with Asch. *Die Silikate in chem. u. technisch. Beziehung*. Berlin (1911).
- Gas exchange in earth's crust: *Proc. Acad. Sci.*, **6**, 141-162 (1912).
- Radioactive ores of earth's crust: *Soc. Adv. Exper. Sci.* H. S. Ledentsov, fasc. **1**, 1-17, Moscow (1912).
- Mineralogy. Part I, pp. 1-134 (3rd ed.). Part II, pp. 1-163, Moscow, (1910). Part II. Third revised and expanded edition, pp. 345-524, Moscow (1912).
- Ueber die gediegenen chemischen Elemente in der Erdkruste: *Cbl. f. Min.*, 758-765 (1912).
- Note on the need of the immediate study of radioactive mineral deposits of Russia: *Proc. Acad. Sci.*, **7**, 976-984 (1913).
- Sur le microcline à rubidium: *Bull. soc. franc. min.*, **36**, 258-264 (1913).
- Materials on spectroscopy of earth's crust. (Problems of concentration and dissemination.) *Proc. Acad. Sci.*, **8**, 989-1008 (1914).
- Note on the study of bismuth deposits: *Ibid.*, **9**, 910-912 (1915).
- Radioactive chemical elements in the crust of the earth: *Applied Medicine*, **3**, 143-196, Petrograd (1915).
- Hydrogen sulfide in earth's crust: *Priroda*. No. 7-8, 941-958 (1915).
- With B. A. Lindener. Materials on spectroscopy of earth's crust. II. *Proc. Acad. Sci.*, **9**, 27-32 (1915).
- On the need of the immediate study of gold deposits by Geological Committee: *Proc. Geological Committee*, **34**, No. 7, 441-452 (1915).
- "Natural productive forces of Russia": *KEP'S Report*, No. **2**, 26-29 (1916).
- Immediate problems of the study of ores of rare metals of platinum group: *Ibid.*, No. **5**, 88-97 (1916).
- On finding of selenium and telurium in Russia: *Tr. of Com. on Source materials*, fasc. **3**, 67-69 (1916).
- Essays of descriptive mineralogy. Sulfide and selenide compounds, vol. **2**, fasc. 1, 1-144 (1917); Fasc. 2, 145-264, Petrograd (1922).
- Note on need of organization of chemical studies of living organism: *Proc. Physico mathematical div. Ukrainian Acad. of Sci.*, part 1, 43-45 (1918).
- Note on study of living matter from geochemical point of view: *Ibid.*, 120-123 (1921).
- Geochemical analysis of soils. Bull. III. All-Russian Conference of Soil Scientists in Moscow, No. 3-4, 1-4 (1921).
- On a new nickel mineral colovratite: *Comp. Rend. Acad. Sci.*, Ser. A., 37 (1922).
- Chemical elements and mechanism of earth's crust: *Priroda*, No. 3-5, 31-40 (1922).
- Sur le problème de la décomposition du kaolin par les organismes: *C. R.*, **175**, 450-452 (Paris 1922).
- History of minerals in earth's crust. Vol. 1, No. 1, *Sci. Him.-Teh. Isd.*, pp. 1-208, Petrograd (1923); fasc. 2, pp. 209-376, I-XX, Leningrad (1927); Vol. 2. History of natural waters, part 1, fasc. I, Goshimtehisdad. pp. 1-201, 8 fig. (1933); Vol. 2, History of natural waters. Part 1, fasc. II, 202-402, Leningrad (1934).

- On anhydride clays (leverrierite group): *Comp. Rend. Acad. Sci.*, Ser. A, 27-29 (1923).
 With B. Lindener. Vanadium: *Him.-Teh. handbook. I. Miner. Resour. Sci. Him-Teh. Isd.*, pp. 16-18 (1923).
 Together with D. I. Scherbakov. Uranium and radium: *Ibid.*, 202-204 (1923).
 Le mendelyevite, nouveau mineral radioactif: *C. R.*, **176**, 993-994 (Paris 1923).
 Aluminosilicates. *Rept. of Brit. Assoc. for the Adv. of Sci.*, Liverpool, September 22-23 (1923).
 On the behaviour of kaolin on heating: *Trans. Ceram. Soc.*, **22**, 398-401 (1922-23).
 La composition chimique de la matière vivante et la chimie de l'écorce terrestre: *Rev. gener. Sci.*, **34**, No. 2, 42-51 (Paris 1923).
 A plan for the establishment of a biogeochemical laboratory: *Trans. of the Marine biol. Stat. of Port Erin*, 38-48 (1923).
 On hydrogen minerals: *Com. Rend. Acad. Sci.*, Series A., 74-76 (1924).
 La Géochimie. Paris. Ed. F. Alcan, pp. 1-404 (1924).
 La matière vivante et la chimie de la mer: *Rev. Gener. Sci.*, Paris, **35**, No. 2, 46-54 (1924).
 With V. Agafonoff. Le produit de la déshydratation du kaolin: *C. R.* **178**, 1082-1084 (Paris 1924).
 With C. Chamié. Sur une pseudomorphose de la curite: *C. R.*, **178**, 1726-1728 (Paris 1924).
 The action of heat on kaolinite and kaolinitic clays: *Trans. Ceram. Soc.*, **24**, 13-22 (1924-1925).
 Determination of chemical energy of (values Δ , V , and e) annual flowering plants. Instruction for determination. *Isd. Acad. Sci.*, No. 1, pp. 1-9 (1926).
 Determination of geochemical energy (values Δ , V , e) of certain groups of insects. Instruction for determination of geochemical constants. *Ibid.*, part 2, pp. 1-10 (1926).
 Sur l'analyse des sols au point de vue géochimie. IV.eme Confer. Internat. de Pédologie, II Commission. Rome. (Abstr. Soil analysis from the geochemical stand-point) pp. 1-8 (1926).
 Sur dispersion des éléments chimiques: *Rev. generl. Sci.* (Paris) **38**, No. 12, 366-372 (1927).
 Mineralogy problems of our country. (1917-1927) *Priroda*, No. 1, 21-40 (1928).
 Rare earths elements of compact rocks: *Com. Rend. Acad. Sci.*, Ser. A, 35-37 (1929).
 On capillary water in rocks and minerals: *Ibid.*, 369-373 (1929).
 Classification and chemical composition of natural waters. *Priroda*, No. 1, 735-758 (1929).
 Travaux sur l'histoire de sciences. L'Academie d. Sci. de l'USSR (1917-1927), *Acad. Sci. Isd.* 173-182 (Leningrad 1929).
 La biosphère. Paris. Libr. F. Alcan, pp. 1-232 (1929).
 Considérations générales sur l'étude de la composition chimique de la matière vivante. Tr. Biogéohim, *Lab. Acad. Sci.*, **1**, 5-32 (1930).
 Geochemie in ausgewählten Kapiteln. Autorisierte Uebersetz aus d. Russischen von Dr. E. Kordes. Leipzig. *Miner. Inst. d. Univers.*, pp. 1-370 (1930).
 Sur la classification et sur la composition chimique des eaux naturelles: *Bull. soc. min. France*, **53**, 417-442 (1930).
 Sur les eaux naturelles riches en radium: *C. R.* (Paris), **190**, 1172-1175 (1930).
 Les isotopes et les organismes vivants: *C. R.*, **192**, 131-133, Paris, (1931); also *The Chem. News*, **142**, 35-36 (1931).
 On coloration of aluminosilicates: *Com. Rend. Acad. Sci.*, Series A, 107-124 (1932).
 Liquid carbon dioxide in ocean water: *Nature*, **129**, 607 (1932).
 Stability of liquid carbon dioxide in the ocean: *Nature*, **130**, 661-662 (1932).
 Sur les conditions de l'apparition de la vie sur la terre: *Rev. generl. Sci.* (Paris) **43**, No. 17-18, pp. 503, 514 (1932).

- Die Radioaktivität und die neuen Probleme der Geologie: *Zeitf. Elektrochem.*, No. **8a**, 519–527 (1932).
- With W. Chlopin. Radium und Mesothoriumhaltige natürliche Gewässer: *Zeit. f. Elektrochem.*, No. **8a**, 527–529 (1932).
- On zones of cooling in the earth's crust. Notice State Hydrol. Inst. Coll. for 25th jubilee of V. V. Glushkov, **10**, pp. 5–16 (French summary) (1933).
- Water equilibrium in earth's crust and chemical elements, *Priroda*, No. 8–9, 22–27 (1933).
- Ozeanographie und Geochemie: *Min. u. petr. Mitt.*, **44**, H. 2–3, pp. 168–197 (1933).
- Quelques considérations sur l'étude chimique des alumosilicates: *Zeits. Krist.*, Abt. A, **84**, H. 5–6, pp. 337–372 (1933).
- With B. Brunowsky, and G. Kunaševa. Sur le Mesothorium dans les Lemna: *C. R.*, **197**, 1556–1557, (Paris 1933).
- Outlines of Geochemistry (Ocherkil geohimii). (2dn Russian Ed.) pp. 1–380 (Leningrad **1934**).
- Ou doit-on chercher l'eau lourde du point de vue géochimique: *C. R.*, **198**, 694–695 (Paris 1934).
- Sur la classification des gaz naturelles: *Bull. soc. france, min.*, **57**, 338–360 (1934).
- Le problème du temps dans la science contemporaine: *Rev. génér. Sci.*, **45**, No. 26, 550–558 (Paris 1934).
- Biosphere and stratisphere. Tr. All-Russ. conference on the study of stratisphere: *Isd. Acad. Sci.*, pp. 575–578 (Leningrad **1935**).
- Problems of biogeochemistry. I. The significance of biogeochemistry in the study of biosphere. 2nd edition. *Ibid.*, pp. 1–47 (1935).
- Radioactivity and new problems of geology. "Fundamental ideas of geochemistry," fasc. 2, *OMTI, Himteoret*, pp. 23–39 (Leningrad **1935**).
- Le problèmes de la radiogéologie. Paris. Hermann et Cie éd., pp. 1–67 (1935).
- Le problème du temps dans la science contemporaine: *Rev. génér. Sci.*, **46**, No. 7, pp. 208–213; No. 11, pp. 308–312 (Paris **1935**).
- Radium geology and its significance for geology of today. International XVII Geol. Congress. USSR session. (Abstract), pp. 190–191 (1937).
- On some fundamental problems of biogeochemistry: *Tr. Biogeochem. Lab. Ac. Sci.*, **5**, 5–17 (1939).
- Some comments on noosphere: *Progress of modern biology*, **18**, No. 2, (1944).
- Goethe as naturalist: (With abridged French Translation), *Bull. Soc. Nat. Moscow*, Sect. Geol., **21**, 5–52 (1946).

PROCEEDINGS OF THE TWENTY-SEVENTH ANNUAL MEETING OF THE MINERALOGICAL SOCIETY OF AMERICA AT CHICAGO, ILLINOIS

C. S. HURLBUT, JR., *Secretary*

The twenty-seventh annual meeting of the Society was held at the Stevens Hotel, Chicago, Illinois, on December 26–28, 1946. The registration figures show that 122 fellows and members attended. The scientific sessions were held in the morning and afternoon of December 27th and in the morning of December 28th, at which 36 papers were presented. The annual luncheon of the Society, which was held on December 27th, was attended by 107 fellows, members, and guests. Following the luncheon Waldemar T. Schaller presented the Roebling medal to Clarence S. Ross. Dr. Ross thus becomes the sixth recipient of this award. The address of the retiring President, Paul F. Kerr, on *Alteration Studies*, was presented in the evening of December 26th.

On the following pages are given the reports of the officers for the year 1946 and the report of the election of officers and fellows for 1947.

ELECTION OF OFFICERS AND FELLOWS FOR 1947

The secretary reports that 399 ballots were cast in the election of officers for 1947; 275 by members, 124 by fellows of the Society. The officers as nominated by the Council were elected and are:

President: Martin J. Buerger, Massachusetts Institute of Technology, Cambridge, Massachusetts.

Vice-President: Carl Tolman, Washington University, St. Louis, Missouri.

Secretary: C. S. Hurlbut, Jr., Harvard University, Cambridge, Massachusetts.

Treasurer: Earl Ingerson, Geophysical Laboratory, Washington, D. C.

Editor: Walter F. Hunt, University of Michigan, Ann Arbor, Michigan.

Councilor (1947–1950): Harry H. Hess, Princeton University, Princeton, New Jersey.

The secretary reports that according to the provisions of the constitution the following have been elected to fellowship:

John S. Brown, Saint Joseph Lead Company, Balmat, New York.

John Roberts Cooper, U. S. Geological Survey, Washington, D. C.

Isidor Fankuchen, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

Walter Pearson Kelley, University of California, Berkeley, California.

Kiguma Jack Murata, U. S. Geological Survey, Washington, D. C.

William Parrish, Philips Laboratories, Inc., Irvington-on-Hudson, New York.

Lester William Strock, Saratoga Springs Commission, Saratoga Springs, New York.

Newman William Thibault, Norton Company, Worcester, Massachusetts.

Charles Robinson Toothaker, Commercial Museum of Philadelphia, Philadelphia, Pennsylvania.

Lawrence Rickard Wager, Durham Colleges in the University of Durham, Durham, England.

William Albert Waldschmidt, Argo Oil Corporation, Midland, Texas.

Aaron Clement Waters, Stanford University, California

Kenneth DePencier Watson, University of British Columbia, Vancouver, British Columbia.

Robert W. Webb, University of California, Los Angeles, California.

Cutler DeLong West, Polaroid Corporation, Cambridge, Massachusetts.

Horace Winchell, Yale University, New Haven, Connecticut.

REPORT OF THE SECRETARY FOR 1946

To the Council of the Mineralogical Society of America:

| MEMBERSHIP STATISTICS | | | | |
|-----------------------|------------|------------|-----------|-----------|
| | 1945 | 1946 | Gain | Loss |
| Correspondents | 5 | 6 | 1 | — |
| Fellows | 218 | 237 | 20 | 1 |
| Members | 549 | 625 | 193 | 117 |
| Subscribers | 344 | 535 | 217 | 26 |
| | <hr/> 1116 | <hr/> 1403 | <hr/> 431 | <hr/> 144 |

The above figures show a net gain of 19 fellows. Sixteen members were elected to fellowship; four fellows were reinstated and one, G. F. Loughlin, was lost through death. A net gain of 76 members and 191 subscribers gives a total gain of fellows, members and subscribers for 1946 of 287. This brings the grand total to 1403, again a new high record.

The large gain in subscribers and to a lesser extent the gain in members was brought about by the increase in foreign subscriptions and the reinstatement of foreign members, particularly from the Soviet Union.

Respectfully submitted,
C. S. HURLBUT, JR., *Secretary*

REPORT OF THE EDITOR FOR 1946

To the Council of the Mineralogical Society of America:

During the current year, practically all colleges and universities have experienced unprecedented student enrollments. The teaching staffs, on the other hand, have not been increased in the same ratio. This unbalanced adjustment has resulted in large classes and heavy teaching assignments which have consumed much of the spare time and energy that under more normal conditions might have been spent in planning research in new fields or continuing projects already begun.

However, in spite of these handicaps, a sufficiently large number of papers have been received to insure a volume for 1946 of slightly more than 600 pages, or an average of about 100 pages for each of the six bimonthly issues. This accomplishment might be considered as fairly satisfactory under the present prevailing conditions.

The current volume is somewhat smaller than that of a year ago, but it should be recalled that the previous volume contained a special symposium number of 14 papers on quartz oscillator-plates. The inclusions of this 264-page special issue was largely responsible for the enlarged size of the volume for 1945. In this connection, it might be noted that the demand for this symposium number has been so great as to require a reprinting of 150 copies of that issue by a lithoprinting process.

The Geological Society has continued its generous financial support for defraying a substantial portion of the publication costs of our journal. This past year, this aid amounted to \$2500 with an additional appropriation, not to exceed \$500, for the cost of colored plates if and when such illustrations were deemed desirable. Recognition and deep appreciation is here expressed for this generous and timely assistance, by virtue of which it was possible to include two colored inserts during the year. A colored plate is also planned in connection with an article by F. H. Pogue and T. H. Rogers on "Experiments in α -ray irradiation of gem stones," which will appear in the January-February number, now in press. In this instance, however, the colored insert is being furnished by the Machlett Laboratories, Inc., of Springdale, Connecticut, without cost to our Society.

During the summer of the current year, our publishers served notice that due to the increased cost of labor and materials, it would be necessary to terminate our old printing contract and enter upon a new one which would step up our printing bill about 16-18%. This action was not entirely unexpected, as we were all aware of the present trend in prices. The executive committee of our Council, after a careful study, considered the new rates reasonable, under present conditions, and voted to continue our cordial relations with the George Banta Publishing Company. This company has served our Society without interruption since 1922.

From time to time, inquiries have been received as to whether a single index will be available covering the ten-year period from 1936 through 1945. Through the efforts of Drs. Ingerson and Fleischer, who have jointly undertaken this task, it can be stated that the decennial index is in preparation and probably will be available sometime during 1947.

In a detailed analysis of the Journal for 1946, we find that volume 31 contains 606 pages, exclusive of index. Leading articles, which number 46, occupy 78.4% of the total space. Table 1, which accompanies this report, indicates the distribution of the leading articles in the various fields listed. The average length of each of the main articles is only 10.4 printed pages.

If to the 46 leading articles we add 17 shorter papers appearing under the heading of "Notes and News," we obtain a total of 63 published manuscripts for the calendar year. These contributions were received from 80 contributors associated with 38 different universities, research bureaus, and technical laboratories.

The Journal for 1946 carries detailed descriptions of two new minerals: tinctite and montbrayite. One hundred and eighty-seven illustrations of various types assist in clarifying the descriptive portions of the text. As in previous years, a number of manuscripts were received from sources outside the States, and in 1946 eight such contributions were printed from the following countries: Canada 4, and one each from Netherlands, England, South Africa, and Australia.

The accompanying Table 1 summarizes in detail the distribution of subject matter in volume 31.

TABLE 1. DISTRIBUTION OF SUBJECT MATTER IN VOLUME 31

| <i>Subjects</i> | <i>Articles</i> | <i>Pages</i> | <i>Per Cent of Total</i> |
|--------------------------------------|-----------------|--------------|--------------------------|
| Leading articles* | | | |
| Descriptive Mineralogy | 9 | | |
| Chemical Mineralogy | 9 | | |
| Structural Crystallography | 6 | | |
| Geometrical Crystallography | 5 | | |
| Petrography | 11 | | |
| Optical Mineralogy | 2 | | |
| Memorials | 3 | | |
| Miscellaneous | 1 | | |
| | 46 | 475 | 78.4 |
| Shorter articles | 17 | 43½ | 21.6 |
| Notes and news | 16 | 10 | |
| Proceedings of Societies | 14 | 70 | |
| Book reviews | 2 | 2 | |
| New mineral names | 18 | 5½ | |
| Total entries | 113 | 606 | 100.0 |
| Illustrations | 187 | | |
| Index, Title page, Table of contents | | 14 | |
| Grand total | | 620 | |

* Leading articles average 10.4 printed pages each.

Respectfully submitted,
WALTER F. HUNT, *Editor*

REPORT OF THE TREASURER FOR 1946

To the Council of the Mineralogical Society of America:

Your treasurer submits herewith his annual report for the year beginning December 1, 1945, and ending November 30, 1946.

RECEIPTS

| | |
|--|-------------|
| Cash on hand December 1, 1945..... | \$ 2,647.70 |
| Dues and subscriptions..... | 4,187.32 |
| Sale of back numbers..... | 1,656.86 |
| Authors' charges on separates..... | 570.31 |
| Interest and dividends from endowment..... | 3,132.00 |
| Payments on principal of Trenton Mortgage stock..... | 130.14 |
| Geological Society of America grant for 1946..... | 2,891.40 |
| Advertisements..... | 310.85 |
| Aid in publishing special articles..... | 952.00 |
| Sale of extra May-June, 1945, numbers..... | 302.79 |
| Sale of 20-volume index..... | 5.00 |
| | <hr/> |
| | \$16,786.37 |

DISBURSEMENTS

| | |
|---|-------------|
| Printing and distribution of the Journal..... | \$ 6,020.35 |
| Printing and distribution of separates..... | 499.16 |
| To the Editor, Secretary, and Treasurer..... | 1,390.00 |
| Postage..... | 463.48 |
| Clerical help..... | 487.37 |
| Office equipment..... | 8.68 |
| Printing and stationery..... | 247.91 |
| Safety deposit box..... | 9.60 |
| Telegram..... | .90 |
| Committee expenses..... | 7.44 |
| Society luncheon (1945)..... | 4.00 |
| Exchange on foreign checks..... | 1.80 |
| Returned check..... | 3.00 |
| Work on index (Vols. 21-30)..... | 240.50 |
| Rights for A. T. & T. debentures..... | 9.36 |
| | <hr/> |
| | \$ 9,393.55 |
| Cash balance November 30, 1946..... | 7,392.82 |
| | <hr/> |
| | \$16,786.37 |

The endowment funds of the Society as of November 30, 1946, consist of the following securities:

BONDS

| | |
|--------------------------------------|-------------|
| 5M U. S. Treasury, 2½%..... | \$ 5,190.63 |
| 5M Illinois Central, 4%..... | 3,887.50 |
| 5M Southern Railway, 5%..... | 5,743.75 |
| 5M Cleveland Union Terminal, 5%..... | 5,068.75 |
| 6M Atlantic Coast Line, 4½%..... | 5,257.50 |
| 4C Great Northern, 5½%..... | 400.00 |

PREFERRED STOCKS

| | |
|---|-----------|
| 50 shares, Virginia Electric & Power Co., 5%..... | 5,942.50 |
| 55 shares, U. S. Steel, 7%..... | 6,946.20 |
| 50 shares, Union Pacific, 4%..... | 4,570.25 |
| 60 shares, Jones & Laughlin, A, 5%..... | 4,987.50 |
| 10 shares, Consolidated Edison..... | 1,066.64 |
| 5 shares, Public Service of New Jersey..... | 702.00 |
| 37 514/1000 shares, Trenton Mortgage Service..... | 1,754.48# |

COMMON STOCKS

| | |
|--|-------------|
| 50 shares, Chesapeake & Ohio Railway..... | 2,368.75 |
| 50 shares, Pennsylvania Railroad..... | 1,468.75 |
| 25 shares, Standard Oil of New Jersey..... | 1,356.25 |
| 25 shares, American Telephone & Telegraph..... | 3,369.32 |
| | <hr/> |
| | \$60,080.77 |

Residual value.

Respectfully submitted,
EARL INGERSON, *Treasurer*

DANA FUND

Disbursements are made to needy mineralogists in war areas, and to needy families of deceased mineralogists in war areas.

RECEIPTS

| | |
|--|----------|
| Available balance, November 30, 1945 | \$943.39 |
| Interest | 6.34 |
| | <hr/> |
| | \$949.73 |

DISBURSEMENTS

| | |
|--|----------|
| Disbursed | \$334.00 |
| Available balance, November 30, 1946 | 615.73 |
| | <hr/> |
| | \$949.73 |

Respectfully submitted,
EARL INGERSO, *Treasurer*

REPORT OF THE AUDITING COMMITTEE

To the President of the Mineralogical Society of America:

The Auditing Committee has examined and verified the accounts of the Treasurer of the Mineralogical Society of America for the fiscal year ending November 30, 1946. The securities listed in the Treasurer's report, with all future coupons on the coupon bonds attached, are in the safety deposit box at the Friendship Branch of the Riggs National Bank of Washington, D. C.

Respectfully submitted,
ALTON GABRIEL
WILLIAM T. PECORA
EDWARD P. HENDERSON, *Chairman*

ABSTRACTS OF PAPERS PRESENTED AT THE TWENTY-
SEVENTH ANNUAL MEETING OF THE MINERALOGICAL
SOCIETY OF AMERICA, CHICAGO, ILLINOIS,
DECEMBER 26-28, 1946

SOME UNITED STATES BOEHMITE LOCALITIES*

VICTOR T. ALLEN

U. S. Geological Survey, Washington, D. C.

The only boehmite locality in the United States listed in the Seventh Edition of Dana's Mineralogy is incorrectly reported to be the Linwood-Barton district, Georgia. More than 200 samples of bauxite and clay from Alabama and Georgia, including some from Linwood, Bartow County, Georgia, were examined by x-ray and optical methods and found to contain gibbsite but no boehmite.

Investigation of alumina hydrates of the United States was started with a grant from the Geological Society of America in 1941 and continued during 1942 to 1946 in connection with the high-alumina clay project of the Geological Survey, U. S. Department of the Interior. The boehmite occurrences reported by H. S. McQueen near Swiss and Stolpe, Gasconade County, Missouri, associated with flint and diaspore clays of Pennsylvanian age, were verified, and the following new localities for boehmite were established: associated with Paleocene gibbsite in black pisolites on the Townsend 40 property, about 2 miles east of Bauxite and near Berger, Pulaski County, Arkansas; as oolites in Pennsylvania flint clay at the Burnt House mine, Olive Hill, Carter County, Kentucky; with kaolinite in the Puget shales of Eocene age at Durham, Kanaskat, and Kummer, King County, Washington; with diaspore at the Cle Elum iron deposit, Kittitas County, Washington; with gibbsite in oolites associated with Paleocene clay at Alberhill, Riverside County, California.

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SOME EXAMPLES OF THE DISTRIBUTION OF FLUORINE IN ROCKS

TOM F. W. BARTH

University of Chicago, Chicago, Illinois

New data of fluorine in rocks and thermal emanations are presented. They corroborate the earlier conclusions of E. S. Shepherd (1940) that fluorine is not an insignificant constituent of the earth's crust; he thinks that about 0.04 per cent F is characteristic of plutonic rocks, lavas run lower, alkaline rocks run higher.

In the plutonic rocks of the (alkaline) Oslo province the average concentration of fluorine is 0.075 per cent (the range is from 0.063 to 0.090). In basalts from Iceland the fluorine content ranges from 0.002 to 0.040, average 0.017 per cent F. In the Oslo kaiaites (formerly erroneously called essexites) the average is 0.070 per cent F.

In the Oslo plutonics fluorine shows no relationship to any other rock-forming element. But in the basaltic rocks very constantly the weight percentage of F is one-tenth that of P_2O_5 , suggesting that apatite in these rocks is the chief carrier of F.

Fluorine in thermal waters of Iceland ranges from zero to 1.45 parts per million. This is about the same as one finds in river waters, but much lower than the figures given by Allen and Day from hot-spring waters of Yellowstone.

Sinter deposits in Iceland contain 0.003 per cent F. Rocks altered by thermal waters are low in fluorine both in Iceland and in the Yellowstone Park. But one rock (from Hverarönd, Iceland, highly altered by fumarole gases) has as much as 0.480 per cent F.

Many more analyses are necessary before the geochemical cycle of this freakish element will be understood.

EUCHROITE AND CHALCOPHYLLITE

L. G. BERRY AND H. R. STEACY

Queen's University, Kingston, Ontario

New observations on euchroite from Libethen, Hungary, and on chalcophyllite from Braden Mine, Chile, combined with existing chemical analyses yield the following data on these minerals:

Euchroite: orthorhombic; disphenoidal— $D_2^4-P2_12_1$; the unit cell, with $a=10.05$, $b=10.50$, $c=6.11$ kX, $a:b:c=0.957:1:0.582$, contains $\text{Cu}_8\text{As}_4\text{H}_{28}\text{O}_{32}=4[\text{Cu}_2\text{AsO}_4(\text{OH}) \cdot 3\text{H}_2\text{O}]$. Specific gravity, measured 3.41; calculated 3.45. Haidinger (1825) obtained orthorhombic elements which, transformed to our setting by interchange of axes, give $a:b:c=0.9635:1:0.5866$. Optical characters; biaxial, positive, $Z=b$, optic plane $\parallel (001)$, $2V=31^\circ$.

Chalcophyllite: hexagonal; scalenohedral, possible space group $D_{3d}^6-R\bar{3}m$; the unit cell, with $a=10.75$, $c=57.40$ kX, $a_{rh}=20.49$ kX, $\alpha=30^\circ 40'$, $a:c=1:5.351$, contains $\text{Cu}_{18}\text{Al}_2\text{As}_3\text{S}_3\text{H}_{99}\text{O}_{87}=\text{Cu}_{18}\text{Al}_2(\text{AsO}_4)_3(\text{SO}_4)_3(\text{OH})_{27} \cdot 36\text{H}_2\text{O}$ in the rhombohedral cell. Specific gravity, measured 2.67; calculated 2.60. Palache (1909) obtained elements in hexagonal notation which, with c doubled, give $a:c=1:5.343$. The museum specimen of chalcophyllite studied here is partially dehydrated with $\omega=1.68$. After exposure to a moist atmosphere for two weeks ω had changed to 1.62, agreeing closely with the observations of Shannon (1924) on fresh material. The partially dehydrated material has a well marked pseudo-cell with $a'=a$ and $c'=c/2$.

LIROCONITE

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X-ray and density measurements on liroconite from Cornwall, England, combined with the existing chemical analyses lead to the following description of this mineral.

Liroconite: monoclinic; prismatic— C_{2h}^0-I2/a ; the unit cell, with $a=12.67$, $b=7.55$, $c=9.86$ kX, $\beta=91^\circ 23'$, $a:b:c=1.679:1:1.306$, contains $\text{Cu}_8\text{Al}_4(\text{As},\text{P})_4\text{H}_{48}\text{O}_{48}=4[\text{Cu}_2\text{Al}(\text{As},\text{P})\text{O}_4(\text{OH})_4 \cdot 4\text{H}_2\text{O}]$ with As:P in the ratio 3:1. Specific gravity, measured 3.01; calculated 3.08. Des Cloizeaux (1859) obtained monoclinic elements which, transformed to our setting by interchange of a and c , give: $a:b:c=1.6808:1:1.3191$; $\beta=91^\circ 27'$. Observed forms $m(110)$, $e(011)$.

GRANITES OF THE FRONT RANGE: PEGMATITES ASSOCIATED WITH THE LONGS PEAK-ST. VRAIN BATHOLITH

MARGARET FULLER BOOS

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Pegmatites are abundant in some areas and very scarce elsewhere in the Longs Peak-St. Vrain batholith and the enclosing metasedimentary formations. At least 90 per cent, by volume, of the pegmatitic material is concentrated in marginal parts of the complex mass of thick granite sheets and cupolaed stocks of the batholith and in contiguous schists. Large bodies of pegmatites show a definite relationship between their size, shape, structure, distribution and certain environmental conditions in and around the batholith.

The parent magma (Silver Plume type) produced granite with marked trachytoid arrangement of the numerous potash feldspar crystals. Locally this habit extended to the offspring pegmatites. Longs Peak pegmatites carry chiefly potash feldspar, glassy to gray quartz, and muscovite. The satellitic Mt. Olympus granite and pegmatite contain original plagioclase feldspar (albite-oligoclase), smoky quartz, and biotite. None of the many hundred pegmatites examined show replacement minerals or hydrothermal textures. The pegmatites of Longs Peak or Mt. Olympus origin did not develop much beyond the magmatic stage.

THE STRUCTURE OF NEPHELINE

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A Weissenberg study of nepheline shows that it belongs to space group $H6_3$ and has cell edges, $a = 10.05 \text{ \AA}$ and $c = 8.38 \text{ \AA}$. The unit cell contains 8NaAlSiO_4 .

The intensities of all reflections which can be recorded with filtered copper radiation were determined using a modified Dawton method. From these data Harker syntheses were prepared and studied in the implication diagrams $I3(xy0)$ and $I6(xy\frac{1}{2})$. This permitted location of all the metal atoms, but the oxygen atoms were insufficiently defined to be located by this method.

Assuming that the metal atoms alone determined the $hk0$ phases, a preliminary electron-density map, $\rho(xy0)$, was prepared. This roughly revealed the oxygen locations. Employing the new atomic locations, the signs of $F(hk0)$ were recomputed and a new electron-density map was prepared. By successive approximations the x and y parameters were arrived at.

The z parameters have been studied first by one-dimensional Harker syntheses, $P(x_1y_1z)$, and later by a series of non-centrosymmetrical electron-density projections through planar sections, such as $\rho(x \ 2/3 \ z)$ and $\rho(x0z)$. The parameters arrived at are as follows:

| | x | y | z (approximate) |
|---------------------------------|-------|-------|----------------------|
| $\text{Na}_1(=\text{K})$ in 2a: | 0 | 0 | 0 |
| Si_1 in 2b: | $1/3$ | $2/3$ | .82 |
| Al_1 in 2b: | $1/3$ | $2/3$ | .18 |
| O_1 in 2b: | $1/3$ | $2/3$ | 0 |
| Na_2 in 6c: | .01 | .43 | 0 |
| Si_2 in 6c: | .09 | .33 | .33 |
| Al_2 in 6c: | .09 | .33 | .67 |
| O_2 in 6c: | .09 | .33 | .50 |
| O_3 in 6c: | .17 | .52 | .75 |
| O_4 in 6c: | .17 | .52 | .25 |
| O_5 in 6c: | .25 | .28 | .25 |
| O_6 in 6c: | .25 | .28 | .75 |

The structure of nepheline proves to be based upon the tridymite structure, with NaAl substituted for half of the Si atoms, as originally predicted by Schiebold. The $\text{Na}_1(=\text{K})$ atoms occupy large holes, and the Na_2 atoms occupy smaller holes produced by collapse of voids in the tridymite structure. Chemical analyses bear out the view that two of the eight alkali atoms are potassium and not sodium, so that the formula of nepheline is really $\text{KNa}_3\text{Al}_4\text{Si}_4\text{O}_{16}$.

The implication diagram $I6(xy\frac{1}{2})$ provides evidence for assuming that the atoms on the three-fold axes are in motion.

CRYSTALLIZATION PHENOMENA IN VOLCANIC EJECTA FROM KILAUEA, HAWAII

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The eruption of Kilauea volcano in Hawaii in May 1924 was of particular interest because it involved many violent explosions, phenomena not common to Kilauean activity. During the eruption a large number of angular blocks of lava were expelled from the volcano's orifice and scattered over the floor of the caldera around the great firepit, Halemaumau.

One particular rock type is a glass-bearing basalt consisting of microphenocrysts of olivine and augite set in a groundmass of labradorite, augite, and basaltic glass, with minor accessories. The labradorite and most of the augite are arranged radially, forming vario-litic structures about 3 millimeters in diameter. Glass fills the interstices between mineral grains.

The texture of the basalt and the paragenesis of its minerals suggest that the normal basaltic magma, from which it was apparently derived, passed through 3 distinct stages in the process of cooling. During Stage 1 the magma cooled slowly and developed microphenocrysts of olivine and augite. Stage 2 began when the magma was intruded as a sill-like mass into the hot walls of the Halemaumau firepit. The magma, now cooling more rapidly, precipitated crystals of labradorite and augite as radial intergrowths. In Stage 3 portions of the intrusion were torn violently from the wall of Halemaumau firepit and hurled high into the air, causing the residual liquid in the pore spaces to be chilled to a glass.

DIFFERENTIAL THERMAL ANALYSIS OF SOME CARBONATE MINERALS

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AND

R. A. ROWLAND

Shell Oil Company, Houston, Texas

Differential thermal analysis curves are presented for ten of the more common carbonate minerals of known purity. The characteristic curves given should aid in detecting the presence of these minerals when they occur in clays or soils being analyzed by this method. The use of differential thermal analysis is suggested for industries utilizing carbonate minerals or their by-products.

SEARLESITE FROM THE GREEN RIVER FORMATION OF WYOMING*

JOSEPH J. FAHEY (with x-ray analysis by JOSEPH M. AXELROD)

U. S. Geological Survey, Washington, D. C.

Searlesite has been found in the drill core of the John Hay, Jr., Well #1 at a depth of 1,480 feet and in the Union Pacific drill core #4 at 1,706 feet, approximately 18 and 20 miles, respectively, west of the City of Green River. This is the third recorded occurrence of searlesite.

Searlesite occurs in low grade oil shale associated with shortite and an undetermined fibrous mineral. Large anhedral crystals 5 cm. across and up to 3 mm. thick lie parallel to the bedding of the shale.

The optical properties of the searlesite from Wyoming agree with those already determined. The indices of refraction were measured in sodium light: $\alpha = 1.525$, $\beta = 1.531$, and $\gamma = 1.535$. X-ray diffraction photographs and chemical analysis identify the Wyoming mineral as searlesite.

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A SIX-TARGET COLD-CATHODE X-RAY DIFFRACTION UNIT

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Using basic designs described by Buerger and Chesley a cold-cathode diffraction unit has been built which, by rotation of a taper sleeve in the side of the tube, gives Cu, Fe, Co, Ni, Cr, or Mo radiation as desired, without disturbance of the operating gas pressure. This feature increases many times the efficiency of work where more than one target is

essential, such as (1) identification by the powder method of crystalline compounds of wide compositional range, (2) precision determination of lattice constants by the single-crystal method. Additional features of this improved equipment are, (1) elimination of auto-transformers and rectification valves, (2) use of a transformer instead of a resistor to control the primary current, (3) permanent seals for the windows (beryllium) and for the glass insulating cylinder, (4) adjustable target-cathode distance, and air-cooling of cathode without a blower, (5) unusually short evacuation line direct to a mechanical pump, with the air intake valve mounted directly on the tube, (6) short target-collimator distance and rigid attachment of camera base to frame of tube.

THERMAL ANALYSIS OF THE MAGNESIUM MINERALS OF THE CURRANT CREEK MAGNESITE DEPOSITS, CURRANT CREEK, NEVADA*

GEORGE T. FAUST

U. S. Geological Survey, Washington, D. C.

Thermal analysis methods were used in connection with the study of the mineralogy and petrology of the Currant Creek magnesite deposits of Nevada. The minerals present are carbonates, hydroxides and basic carbonates and of the hydrous magnesium silicates. Some relationships with other occurrences of related minerals are outlined.

* Published with the permission of the Director, Geological Survey, U. S. Department of the Interior.

THE UNIT CELL OF GLAUDODOT

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A large typical crystal of glaucodot (Co, Fe)AsS, from Hakansbö, Sweden, shows a good prismatic cleavage (110) and a poor pinakoidal cleavage (001), in the preferred original setting. Rotation and Weissenberg photographs on a cleavage fragment turned about [001] show no significant departure from orthorhombic symmetry and lead to a C-type cell with $a=6.63$, $b=28.33$, $c=5.63$ kX, $Z=24$, $G=6.15$ (calc. for Co:Fe=1:1), 6.06 ± 0.05 (meas. Frondel). Additional abnormal systematically missing spectra indicate, however, that this is an apparent lattice due to two coexisting rectangular lattices: I, P-type, with $a'=a/2$, $b'=b/2$, $c'=c$, $Z'=6$; II, C-type, with $a''=a$, $b''=b/3$, $c''=c$, $Z''=8$. The lattice II, which is the weaker, compares with that of arsenopyrite ($a=6.42$, $b=9.51$, $c=5.65$ Å, Buerger) and is clearly reflected in the morphology. The only existing cell dimensions for glaucodot are $a=6.67$, $b=4.81$, $c=5.73$ Å (de Jong, powder method).

THREE-DIMENSIONAL PROJECTION IN GEOLOGICAL TRAINING

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In November 1940 the writer built a twin projector* using 500-watt bulbs, each objective carrying a polaroid plate. This was fitted to take 2 by 4½-inch glass slides in which were mounted a stereoscopic pair of photographs made on standard (double frame) 35 mm. film, either black and white or colored. Later a simple stereoviewer, with which students could individually study the stereoslides was described†. Brief directions for taking stereophotographs with a single-lens camera and for mounting stereopairs in slides to be used for projection purposes were included.

* Fisher, D. Jerome, Projector for Stereoscopic Pictures, *Amer. Jour. Physics*, 10 (1), Feb. 1942, 46-49.

† ———, Stereoscopic Projection and Map Reading. *Amer. Jour. Sci.*, 240, Sept. 1942, 642-648.

The writer now has nearly 500 stereoslides, many in color. A small selection from these will be shown on the University of Chicago campus to limited groups on Saturday, December 28, as noted in the program. Besides illustrating various subjects by means of vertical aerial photographs, some of which are accompanied by matching contour maps or terrestrial stereophotos, slides will be shown of applications to morphological, optical, physical, and structural crystallography. This occasion will also be taken to demonstrate a simple (non-stereoscopic) projection of the famous Mitscherlich experiment on a modified piece of standard apparatus; this presents in color the decrease of optic axial angle (to uniaxiality) in gypsum with rise in temperature.

There is need for cooperation in preparing stereoslides for use in the various phases of geological instruction. Block diagrams and structural interpretations are obvious fields. There should be many possibilities for phantom stereopairs, such as would show an indicatrix properly placed inside a crystal drawing. These may also be made by photography—for instance, the photograph of an armature and then the motor casing to fit around it (double exposure stereophotography). The writer would like to hear from those interested in stereoscopic work as applied to the geological sciences, and would be glad to exchange copies of suitable stereophotographs.

TOURMALINE PRESSURE GAUGES

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During the war years, single crystals of tourmaline were an important industrial raw material for use in piezoelectric gauges for the measurement of blast pressures in air and under water. The gauges comprise thin discs of tourmaline from $\frac{1}{4}$ inch up to several inches in diameter cut perpendicular to the *c*-axis and used singly or in stacks. The design and construction of the gauges is described in detail. The piezoelectric response of the tourmaline to the transient pressure wave is amplified and recorded on associated electronic equipment and both the magnitude of the pressure and the wave-form deduced thereby. Transient gauge-pressures of less than an ounce to over 40 tons per square inch have been investigated by such means.

The sources of supply, price, and factors determining the usability of raw tourmaline for the purpose are discussed. Tourmaline for radio oscillator-plates must be entirely free from imperfections, and requires crystals of gem quality, but material for gauges can contain a considerable amount of cracking. Most of the tourmaline employed was of low-iron, high-alkali types from Brazil and Madagascar and the domestic production was negligible. Black tourmaline is generally unsuitable. Crystals over two inches or so in cross section were in particularly short supply. Such crystals are used in the construction of air-blast gauges, in which the relatively low incident pressure, at most only a few hundred psi, must be compensated by increased surface area of the discs in order to obtain an adequate signal. Tourmaline is responsive piezoelectrically to hydrostatic pressure and because of this and its high mechanical strength and chemical stability is used in preference to quartz and various water-soluble salts such as ADP and Rochelle salt.

MINERALS OF STEAMBOAT SPRINGS, NEVADA

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University of Nevada

AND

DONALD E. WHITE

U. S. Geological Survey

Recent studies at Steamboat Springs have brought to light many features of interest to geologists. Many minerals have been found that have not been previously reported from

the area. Deposition of stibnite and gold at the surface is of frequent occurrence and mercury has been detected in the gases. Cinnabar, notwithstanding published statements to the contrary, is found abundantly in the siliceous sinter. Sulfides, deposited in granodiorite have been oxidized with the formation of sulfuric acid and numerous sulfates of copper and iron. The descending sulfate-bearing meteoric water encounters heated vapors with the resulting deposition of supergene sulfides. The combined action of the meteoric water and the hot vapors causes intense alteration of granodiorite and basalt. The resulting end product consists largely of quartz, opal, chalcedony, and clay minerals.

SODIUM BICARBONATE (NAHCOLITE) FROM GARFIELD COUNTY, COLORADO*

JEWELL J. GLASS

U. S. Geological Survey, Washington, D. C.

A notable occurrence of colorless, transparent, crystalline sodium bicarbonate, nahcolite (NaHCO_3) has been found in the Mahogany oil-shale bed in the Green River formation (Eocene), Garfield County, Colorado. The nahcolite was found in cavities in pods or pockets of "salt crystal" masses in the shale at a depth of 412 feet. The pockets range in size from 6 inches to 2 feet in diameter. Nahcolite occurs as crystalline masses which break easily into tabular cleavage pieces many of which show rhombic outline similar to calcite. Nahcolite is monoclinic. It has a vitreous luster. Brittle; fracture conchoidal. Cleavage in three directions; one (010) perfect, two good.

Optically the mineral is biaxial negative, $2V=77^\circ$ (Ca.). Dispersion is distinct, v greater than r . Cleavage pieces parallel to the perfect cleavage give a well centered biaxial figure, showing that the acute bisectrix X is normal to, or nearly normal to, the cleavage. The plane of the optic axes is parallel to the perfect cleavage. The indices of refraction are: $\alpha=1.374$, $\beta=1.499$, $\gamma=1.583$. $B=.209$.

This is the second verified occurrence of free sodium bicarbonate as far as is known, the first being at Searles Lake, California.

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CHALCOSIDERITE AND TURQUOISE

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An x-ray study of chalcosiderite from Wheal Phoenix, Cornwall, and turquoise from Campbell County, Virginia, combined with existing analyses, yields the following descriptive data:

Chalcosiderite: triclinic-pinacoidal; unit cell, with $a=7.66$, $b=10.18$, $c=7.88$ kX, $\alpha=112^\circ29'$, $\beta=115^\circ18'$, $\gamma=69^\circ00'$, $a:b:c=0.7525:1:0.7741$, contains $\text{CuFe}_6(\text{PO}_4)_4(\text{OH})_8 \cdot 4\text{H}_2\text{O}$. Specific gravity, measured 3.22; calculated 3.26. Maskelyne (1875) obtained elements which, transformed to our setting, give $a:b:c=0.7505:1:0.7703$, $\alpha=112^\circ18'$, $\beta=115^\circ18'$, $\gamma=68^\circ32'$.

Turquoise: triclinic-pinacoidal; unit cell, with $a=7.47$, $b=9.93$, $c=7.67$ kX, $\alpha=111^\circ39'$, $\beta=115^\circ23'$, $\gamma=69^\circ26'$, $a:b:c=0.7523:1:0.7724$, contains $\text{CuAl}_6(\text{PO}_4)_4(\text{OH})_8 \cdot 5\text{H}_2\text{O}$. Specific gravity, measured 2.84; calculated 2.95. Schaller (1912) retained Maskelyne's chalcosiderite elements for turquoise.

IMPROVED APPARATUS FOR DOUBLE-VARIATION PROCEDURE

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In working with the double variation method for refractive index determination as proposed by Emmons, several difficulties are encountered which somewhat complicate the

procedure. These are chiefly the inability to control the temperature accurately; the collection of bubbles in the water cell on the stage; and the necessity of using an arc light for illumination. The first two difficulties have been eliminated by constructing a simple recirculating system in which a small volume of water free from air is used continuously. The temperature of this water is controlled by a thermostat that can be adjusted for any predetermined value.

An arc has been necessary so that monochromatic light of sufficient intensity could be obtained with a monochromator. A new type of transmission interference filter is now available which enables one to obtain light of a given wave length of high intensity using a lamp with an incandescent element.

LIQUID INCLUSIONS IN GEOLOGIC THERMOMETRY

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Most vein minerals and many of those in igneous rocks contain liquid inclusions. A satisfactory method of determining temperatures of crystallization from the liquid inclusions would aid in the solution of many problems of geologic thermometry.

Recent data on the specific volume of water at high temperatures and pressures allow much more accurate determination of the effect of pressure than has been possible before, and data on the critical temperatures of aqueous solutions of alkali halides provide the basis for better evaluation of the effect of concentration.

Curves have been prepared showing the relation of degree of filling of inclusions and temperature of disappearance of the vapor phase, both for pure water, and for a 10 per cent solution. A series of curves shows the relation between the temperature of disappearance of the vapor phase, pressure at the time of formation and temperature of formation.

For vein and pegmatite quartz studied, where pressures can be estimated from the amount of overburden at the time of formation, pressure corrections range from about 45° to 90°C.

THERMAL ANALYSIS OF MISSOURI FIRE CLAYS

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Mineralogical determinations by the thermal analysis method were made of a wide variety of Missouri fire clays and the clay fractions of several other argillaceous sediments. The common hard flint fire clay gives a typical kaolinite curve, but the so-called "soft flints" show both endothermic and exothermic reactions at slightly lower temperatures than does kaolinite. Some plastic fire clay is dominantly kaolinite but curves of other varieties indicate mixtures, possibly montmorillonite with kaolinite. The high alumina clays contain kaolinite, diaspore, gibbsite, and boehmite.

A clay from loess is illite, and clays from shale suspensions give illite and kaolinite reactions. Comparative curves of the clays are shown.

"ALTERATION STUDIES"

PAUL F. KERR

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Leaders in mineral industry are becoming aware of the need for improvement in the methods of mineral exploration. Among different techniques which have appeared from a variety of sources, the so-called "alteration studies" provide one avenue along which to approach the problem of enlarging our known mineral reserves.

The technique of alteration study is one of combined field and laboratory investigation. The laboratory work is based to a considerable degree upon the methods and results of in-

vestigations of the clay minerals. These studies have accumulated data and methods now proving generally applicable.

Alteration studies have been undertaken in a number of the more important mining districts of the west of late. Investigations to date are more or less experimental in scope, but results secured in certain localities suggest that the transition to a stage of broader application may be near at hand.

CLINOHUMITE AND ASSOCIATED MINERALS FROM DILLON, MONTANA*

MARIE LOUISE LINDBERG

U. S. Geological Survey, Washington, D. C.

Clinohumite from Dillon, Montana, occurs as aggregates several centimeters thick of red anhedral grains in an enstatite rock associated with actinolite, anthophyllite, spinel, magnetite, clinocllore, phlogopite, and forsterite. Its indices of refraction with sodium light are: $\alpha=1.655$, $\beta=1.678$, $\gamma=1.700$. $2V$ is very close to 90° . The dispersion is strong. The pleochroism is X=orange, Y=pale orange, Z=yellow.

The earliest minerals to form are spinel, forsterite, and enstatite. Spinel is poikilitically enclosed in enstatite. Phlogopite, actinolite, and anthophyllite invade the forsterite and enstatite. Spinel is greatly attacked when actinolite was introduced. Clinohumite is one of the latest minerals to form, and replaces forsterite almost completely. Excess iron from the formation of actinolite and clinohumite is found as magnetite. Clinocllore is associated with the clinohumite and magnetite.

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THE PEÑA BLANCA METEORITE, BREWSTER COUNTY, TEXAS

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The Peña Blanca meteorite fell August 2, 1946, in the swimming pool at the headquarters of the Gage Ranch near Marathon in Brewster County, Texas. Twenty-four people were within a few hundred feet of the point of fall, and one person saw the meteorite in flight.

Approximately 70 kg. (152 lbs.) of the meteorite was recovered consisting of one fragment of 47 kg. (104 lbs.), one fragment of 13 kg. (29 lbs.) and many smaller pieces down to mere grains. Reconstruction of the shape indicates that all but a few pounds of the stone have been recovered.

The meteorite is a white achondrite with a cream colored crust and remarkable porphyritic texture. One phenocryst of pyroxene is $10\times6\times6$ cm., another is $6\times3\times3$ cm., and a number are larger than $3\times3\times3$ cm. The groundmass shows considerable variation in grain size with abundant smaller grains 0.15 mm. in size.

Orthorhombic pyroxene is the principal constituent of the meteorite. Monoclinic pyroxene and olivine are of secondary importance. A very small amount of metal and sulfide is present, and there is a trace of plagioclase feldspar.

AN IMPROVED METHOD OF COUNTING OUT PETROFABRIC DIAGRAMS

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In place of the conventional center and peripheral counters, a single sheet of millimeter graph paper is used on which a small number of suitably arranged 1 per cent counting circles (1 cm. diameter) are drawn in ink. The point diagram is plotted on transparent cellulose acetate and provided with a tracing paper overlay upon which the contour diagram is drawn. Counting out involves successive 360° rotations of the superposed point diagram about a few appropriate centers marked on the grid. The counting circles and their centers

are readily visible through the overlays and indicate the desired 1 per cent counting areas for all positions of rotation. Percentage figures appear in circular arcs $\frac{1}{2}$ cm. or $\frac{1}{4}$ cm. apart, depending upon accuracy required, and concentric about the center of the diagram. Peripheral counts are made by utilizing opposing pairs of complementary circle segments drawn on the same grid. Similar provisions are made for azimuth counts.

This procedure is not only more rapid than the present method, but also reduces fatigue resulting from constant shifting and centering of the conventional counters. Its particular advantage lies in greater accuracy of contouring, since continuous rotation of the point diagram permits determination of the critical loci of change in percentage figures.

THE USE OF KODACHROME SLIDES IN TEACHING ELEMENTARY MINERALOGY AND LITHOLOGY

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During the past year the number of students taking elementary mineralogy and lithology at the University of Toronto has become so great that the author has found it impracticable to continue illustrating his lectures with actual specimens. Instead, a library of Kodachrome slides has been built up and these are projected on the screen. This method has the advantage of placing before the students specimens of the finest quality on a scale where the details may be observed clearly by all simultaneously and without damage to the specimens.

FUSED WOOD-ASH STONES: FAIRCHILDITE (n.sp.) $K_2CO_3 \cdot CaCO_3$, BUETSCHLIITE (n.sp.) $3K_2CO_3 \cdot 2CaCO_3 \cdot 6H_2O$, AND CALCITE, $CaCO_3$, THEIR ESSENTIAL COMPONENTS

CHARLES MILTON AND J. M. AXELROD

U. S. Geological Survey, Washington, D. C.

Stones found in the trunks of standing partially burned forest trees are produced by fusion and subsequent crystallization of the ash of the wood. Freshly formed stones consist essentially of fairchildite; on wetting, or by atmospheric hydration this is converted to buetschliite and calcite. On further leaching, the buetschliite is decomposed to calcite and water-soluble potassium carbonate. The presence of the first three carbonates in wood-ash stones is established, and a general account of these with a review of pertinent literature is given in this paper. The artificial compounds corresponding to fairchildite and buetschliite were prepared and analyzed by Otto Buetschli, in 1901–1905, but have not hitherto been found in nature. Fairchildite is hexagonal, $\epsilon = 1.48$, $\omega = 1.530$, and buetschliite is probably also hexagonal, with $\epsilon = 1.455$, $\omega = 1.595$.

NUEVITE, A NEW RARE-EARTH MINERAL FROM CALIFORNIA

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A heavy black mineral from the Southern Pacific Silica quarry near Nuevo, Riverside County, California, is shown to be a titano-niobate of yttrium and iron, with an additional fractional per cent of tantalum. Spectroscopic analysis fails to show other rare elements, even in traces. The mineral thus appears to be a very simple member of the eschinite, samarskite, polycrase-euxenite group. It differs notably from any of the known species of this group, and thus seems to be a new mineral, for which the name "nuevite" is proposed.

Its properties are as follows: crystals prismatic in habit, square or rectangular, with orthorhombic (?) symmetry. Color black, highly brilliant on fresh fracture. Nearly opaque, but transparent brown in very thin flakes. No cleavage. Fracture flat conchoidal. H 6.5, G 6.4. Optically isotropic, index 2.23. Fusible, yielding a little water in closed tube.

It occurs in grains and crude crystals in quartz, associated with a little cyrtolite and black tourmaline.

ZONES AND REPLACEMENT BODIES IN THE HUGO PEGMATITE,
KEYSTONE, SOUTH DAKOTA

JAMES J. NORTON AND LINCOLN R. PAGE

U. S. Geological Survey, Washington, D. C.

The Hugo pegmatite, one mile south of Keystone, South Dakota, crops out as an irregular body about 580 feet long and 480 feet wide. It consists of two zoned segments separated in part by quartz mica schist. The long axis of the outcrop trends northwest, but the individual segments strike east-northeast and dip north. Apparently the northern segment thickens and the southern segment thins with depth.

Three types of structural units of pegmatite are recognized: zones, fracture fillings, and replacement bodies. The essential minerals of the zones from the pegmatite contact inward are: (1) oligoclase and quartz; (2) quartz, oligoclase-albite, and muscovite; (3) quartz, albite, and perthite; (4) quartz, cleavelandite, perthite (and microcline), and amblygonite; (5) quartz, microcline, and spodumene; (6) quartz and microcline; and (7) a core of cleavelandite, microcline, and lithia mica. Zone 3 is divided into three sub-zones on a basis of the proportion of perthite. The northern segment contains only zones 1 through 4.

Fracture fillings and replacement bodies of quartz-cleavelandite-perthite (and microcline), cleavelandite-quartz-lithia mica, and cleavelandite-quartz-microcline-lithia mica pegmatites cut all zones except the core. The largest replacement body is an offshoot of the core and crosses three zones that can be recognized by relict textures and minerals. Textures of the replacement bodies are distinguishable from the earlier replacement textures formed as the zones were first becoming consolidated.

Variations in composition of individual minerals and the abundance of replacement textures are correlated with the sequence of structural units.

RELATION OF PARAVAUXITE AND GORDONITE

E. W. NUFFIELD

University of Toronto, Toronto, Ontario

Paravauxite was described by Gordon as a triclinic mineral with the composition $\text{FeO} \cdot \text{Al}_2\text{O}_3 \cdot \text{P}_2\text{O}_5 \cdot 11\text{H}_2\text{O}$ (1922) or $\text{FeO} \cdot \text{Al}_2\text{O}_3 \cdot \text{P}_2\text{O}_5 \cdot 10\text{H}_2\text{O}$ (1944). Gordonite is the name given by Larsen & Shannon to the crystallographically similar mineral with the composition $\text{MgO} \cdot \text{Al}_2\text{O}_3 \cdot \text{P}_2\text{O}_5 \cdot 9\text{H}_2\text{O}$ (1930). Determinations of the unit cells of these two minerals, from sharp rotation and Weissenberg photographs, gave the following results in comparison with previous crystallographic data:

| | <i>a</i> | <i>b</i> | <i>c</i> | | | | |
|-------------|----------|----------|----------|---|----------|----------|---------|
| Paravauxite | 5.23 | 10.52 | 6.955 kX | } | 107°16½' | 111°24' | 72°29' |
| | 0.4966 | : 1 | : 0.6609 | | | | |
| | 0.4840 | : 1 | : 0.6882 | | | | |
| | | | | | 107°32' | 110°23' | 72°09' |
| Gordonite | 5.22 | 10.49 | 6.95 kX | } | 107°29' | 110°55½' | 72°32½' |
| | 0.4975 | : 1 | : 0.6628 | | | | |
| | 5.25 | 10.49 | 6.97 | | | | |
| | 0.5004 | : 1 | : 0.6644 | | | | |
| | 0.5192 | : 1 | : 0.6942 | | | | |
| | | | | | 109°27' | 110°57½' | 71°40½' |

(1) E.W.N., *x*-ray. (2) Gordon, gon., preliminary values (1944), transformed. (3) E.W.N., *x*-ray. (4) Larsen III, *x*-ray (1942). (5) Pough, gon. (1937).

With $\text{FeO} \cdot \text{Al}_2\text{O}_3 \cdot \text{P}_2\text{O}_6 \cdot 9\text{H}_2\text{O}$ in the unit cell, *G* (calc.) for paravauxite is 2.375 compared to 2.358 (meas., Gordon) and this composition is also consistent with the recent analyses.

ELLIPSOIDAL STRUCTURES IN GLASS

E. F. OSBORN

Pennsylvania State College, State College, Pennsylvania

Some novel optical glasses made recently contain ellipsoidal structures similar in many respects to pillow lava structures. The structures are shaped by convection currents in the liquid. The border of the ellipsoidal structures is schistose and commonly remains a glass even though the interior crystallizes. The difference in rate of crystallization of border and interior is a result of a difference in chemical composition and rate of cooling.

TWO SIMPLE TRANSFORMATIONS OF BRAVAIS SYMBOLS

ARTHUR L. PARSONS

Royal Ontario Museum of Geology and Mineralogy, Toronto, Ontario

Simple transformation of Bravais symbols demands two zero points. Of the 144 possible simple transformations of Bravais symbols from $a_1 a_2 a_3$ axes to a'_1, a'_2, a'_3 axes, referred to all possible zero points, with clockwise and counter clockwise succession of axes, there are twelve types, one of which is in simple accord with the transformation equation

$$\tan^2 \rho - 3x^2 \cdot c/3a^2 = y^2 \cdot c^2/3a^2$$

where

$$\tan^2 \rho = \frac{4h^2 + 4hk + 4k^2}{l^2} \cdot \frac{c^2}{3a^2}$$

and

$$x = h/l \text{ or } k/l \text{ or } (h+k)/l$$

and

$$y = (h+2k)/l \text{ or } (2h+k)/l \text{ or } (h-k)/l$$

This type transforms $(hk\bar{l})$ to $([h+2k] \cdot [2h+k] \cdot [\bar{h}-k] \cdot l)$ or $(\bar{h}'k'\bar{l}')$.

Another type transforms $(hk\bar{l})$ to $(h'k'\bar{l}')$. The other ten types are only briefly discussed. All are in accord, graphically, with the transformation equation, but, in general, the assignment of the transformed indices to the proper axes requires reference to the gnomonic projection.

CONTACT METAMORPHIC MINERALS IN THE MELTING OF OPTICAL GLASS

WILLARD H. PARSONS

Wayne University, Detroit, Michigan

AND

HERBERT INSLEY

Bureau of Standards, Washington, D. C.

Petrographic studies made at the National Bureau of Standards on the attack by various optical glasses on refractory clay pots revealed the presence of crystalline compounds analogous in composition and properties to several natural minerals. The description of the compounds found, together with data on the conditions and associations in which they were found, may give clues as to the source of the corresponding minerals. With barium glasses, celsian formed as bladed crystals at the pot-glass interface and also was abundant within the corroded refractory. Sanbornite was present sparingly with the celsian but was more commonly found as devitrification stones in the glass itself. Zinc spinel developed in the refractory as small, perfect octahedrons. Nephelite-kaliophillite and carnegieite solid

solutions were present as reaction rims at the pot-glass interface. Mullite occurred abundantly in needles, corundum in thin, pleochroic plates, and cristobalite in skeletal crystals.

The formation of corundum by the action of a melt containing silica and alkalis on an aluminum silicate wall material is explained by the phase relationships in the system $\text{Na}_2\text{O}-\text{Al}_2\text{O}_3-\text{SiO}_2$ and may be similar to the origin of corundum at the contact of synenite with aluminum silicate country rock. The presence of celsian and sanbornite in the refractory may also parallel natural occurrences in contact zones. Nephelite and carnegieite solid solutions occur together only at high temperatures under known equilibrium conditions. The formation of zinc spinel by glasses with only 3 per cent of zinc is in accordance with the large field of zinc aluminate in the system $\text{SiO}_2-\text{ZnO}-\text{Al}_2\text{O}_3$.

INDEXED X-RAY POWDER SPECTRA OF THE ORE MINERALS

M. A. PEACOCK

University of Toronto, Toronto, Ontario

A satisfactory standard x-ray powder spectrum consists of good reproductions of powder films made on authentic natural and, if possible, artificial material with Cu/Ni or Fe/Mn radiation, accompanied by a table giving the unit cell constants (corrected if necessary), the observed intensity of each powder ring on a scale of 10, the measured glancing angle, the measured interplanar spacing, the indices (*hkl*) of the reflecting planes, and the calculated spacing. A full set of such spectra is being prepared in Toronto to supplement existing röntgenographic data for the identification of the ore minerals.

NEW CHARTS FOR TEACHING CRYSTALLOGRAPHY

TERENCE T. QUIRKE

University of Illinois, Urbana, Illinois

Charts have been prepared on the basis of Mauguin's system as used in the International Tables. One chart is drawn to illustrate forms characteristic of the 32 classes, indicating the elements of symmetry for each class. Another chart lists in parallel rows, names of classes according to three representative nomenclatures, the number of faces in the form, the elements of symmetry, the symmetry notations, with the addition of the space lattice groups pertaining to each crystal class and point group. These charts make a very convenient reference and have proved to be a great aid in teaching crystallography.

PREPARATION OF RUTILE TITANIUM DIOXIDE

TERENCE T. QUIRKE AND ROBERT STEINMAN

University of Illinois, Urbana, Illinois

Rutile occurs in nature in low temperature quartz, but seems not to be stable synthetically below 1040°C. By heating anatase intimately ground with another compound of the rutile lattice structure to 900°C. for two hours part conversion to rutile was achieved within the brookite range. However, with the addition of SiO_2 almost perfect conversion to rutile was accomplished in nearly every case. Germanium dioxide was also found to be efficacious.

The use of silica to coerce the formation of the rutile structure differs from the common use of seed crystals in that it involves the mutual packing effects of lattices which are not isomorphous. In this respect the procedure is thought to be unique.

THE COMPOSITION AND UNIT CELL OF HYDROZINCITE

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Specimens of hydrozincite from Goodsprings, Nevada, show tiny crystals projecting from fine-grained massive material. The crystals are blade-like, and taper to a sharp point.

They are up to 2 mm. in length, slender, and very thin. The only well-developed form is the pinacoid {100}. Edge faces give very indistinct reflections on the goniometer, and no measurable terminal faces were observed. Weissenberg photographs confirm the previous assignment to the monoclinic system. The space group is either C_2/m , C_m or C_2 , the characteristic missing hkl reflections being those with $h+k$ odd. Unit cell dimensions, derived from 0-level, b - and c -axis rotations, are: $a=13.452$ kX, $b=6.307$, $c=5.357$; $\beta=95^\circ30'$ (x -ray). The volume of the unit cell, together with the values of d given in the literature, 3.6–3.8, do not give any simple proportions of $Zn(CO_3)$ and $Zn(OH)_2$. Tests in Clerici solution indicate a d close to 4.0, and this agrees well with a unit cell composition of $4Zn(CO_3) \cdot 6Zn(OH)_2$.

Crystals of aurichalcite from the Magdalena district, New Mexico, closely resemble those of hydrozincite, except for their pale green color. However, Weissenberg photographs indicate that, although closely related, aurichalcite is not isomorphous with hydrozincite.

URANINITE CRYSTALS WITH A NEW FORM FROM PORTLAND, CONNECTICUT

AUSTIN F. ROGERS

Stanford University, California

Euhedral crystals of uraninite from one of the pegmatites at this locality are octahedra modified by the cube, the dodecahedron, and a new form, the tetrahexahedron {520}. The latter is determined on a matrix specimen by measurement on the microscope stage of the plane angle formed on the {520} face by its intersections with {111} and {11 $\bar{1}$ }, which may be expressed as the interzonal angle $[2\bar{5}3] \wedge [\bar{2}53]$.

The uraninite crystals occur on a matrix of feldspar which proves, on optical examination, to be albite with the approximate composition $Ab_{95}An_5$. The albite is a replacement of microcline, which is present in very small amounts as a relict mineral.

Besides the usual cleavages parallel to {001} and {010}, the albite shows fair cleavage parallel to {110}, and both albite and pericline twin-lamellae, as well as pericline parting.

URANINITE AND PITCHBLEND

AUSTIN F. ROGERS

Stanford University, California

It is proposed to use the name uraninite for the crystalline (isometric), essentially uranium dioxide (UO_2) mineral, with specific gravity varying from about 8.0 up to about 10.5 and low water content, and the name pitchblende for its massive or colloform amorphous equivalent (mineraloid) with a specific gravity varying from about 6.8 up to about 8.5 and a water content varying from about 2 per cent up to 5 per cent.

PRELIMINARY DATA ON IRON-BEARING MELILITES IN THE QUATERNARY SYSTEM $Ca-FeO-MgO-SiO_2$

J. F. SCHAIRER AND E. F. OSBORN

Geophysical Laboratory, Washington, D. C.

A few compositions have been studied in a small portion of the join $CaSiO_3-MgO-FeO$ in the quaternary system $CaO-FeO-MgO-SiO_2$. Compositions between akermanite ($Ca_2MgSi_2O_7$) and its iron analogue ($Ca_2FeSi_2O_7$) and between monticellite ($CaMgSiO_4$) and its iron analogue ($CaFeSiO_4$) lie in this join. The phase relations for the join have been roughly outlined and the optical properties of the melilites have been determined. There is a continuous series of melilites between akermanite (optically uniaxial and positive) and its iron analogue (optically uniaxial and negative). The intermediate member containing approximately 72 weight per cent of akermanite is isotropic for sodium light.

HYDROTHERMAL ALTERATION IN THE "PORPHYRY COPPER" DEPOSITS*

GEORGE M. SCHWARTZ

University of Minnesota, Minneapolis, Minnesota

The hydrothermal alteration which was accompanied by the introduction of copper sulfides in the disseminated copper deposits is considerably more complex than is generally recognized.

Detailed microscopic study of selected porphyry specimens from the important producing deposits in the United States, together with a review of published data, leads to the recognition of four main types of alteration which may be characterized as follows:

1. Quartz-orthoclase.—Alteration to and/or introduction of quartz and orthoclase with a fairly favorable ratio of chalcopyrite to pyrite. Ajo, Ely, Bagdad, Utah Copper (in part).
2. Quartz-sericite-pyrite. Inspiration-Miami, Ray, Sacramento Hill, Castle Dome (in part), Utah Copper (in part).
3. Sericitic and argillic alteration with quartz subordinate. Morenci, Chino, Castle Dome (in part), San Manuel.
4. Biotitic alteration. Utah Copper (in part) and Ely (in part).

No district is a simple example of one kind of alteration but shows a dominance of one or two of the above types. Most districts show a rather long list of alteration products when studied in detail.

The argillic alteration has been little emphasized in earlier work but is now found to be very important in several districts of which Morenci is an outstanding example. The clay minerals are found in the sulfide ore and are characteristically earlier than sericite.

The more important clay minerals include: hydromuscovite, kaolinite, allophane, halloysite and beidellite. Less common are: potash clay, montmorillonite, and dickite.

Available chemical data indicate that calcium and sodium are usually removed from the rock to a significant degree, and potassium remains constant or increases. Silica is gained in a few deposits but usually shows minor changes. Quartz, no doubt, is often formed by the freeing of silica during alteration.

* Published by permission of the Director, Geological Survey, United States Department of the Interior, Washington, D. C.

PUMICE FROM HAYLMORE, BRIDGE RIVER, BRITISH COLUMBIA

LOUISE STEVENS STEVENSON

Victoria, British Columbia

Pumice of Recent age from Haylmore's placer mine, Bridge River district, British Columbia, is highly vesicular and also shows pronounced fluidal structure. The pumice is vitrophyric; the volcanic glass of the groundmass has a refractive index of 1.497. The principal phenocrysts are plagioclase feldspars ($Ab_{70} An_{30}$) characterized by an abundance of glass inclusions. Glistening black hornblende phenocrysts are also found. A chemical analysis of the pumice and results of x-ray studies are given.

**GEOLOGY OF THE RED ROSE TUNGSTEN MINE
HAZELTON, BRITISH COLUMBIA***

JOHN S. STEVENSON

British Columbia, Department of Mines

The Red Rose mine was British Columbia's largest producer of tungsten during World War II.

Scheelite occurs in a shear-zone that cuts Mesozoic Coast Range intrusives and hornfelsed tuffs within 750 feet of the Rocher Déboulé batholith.

* Published with the permission of the Chief Mining Engineer, B.C. Department of Mines.

The minerals include scheelite, some ferberite and, in order of abundance: quartz, orthoclase, albite, apatite, biotite, hornblende, chalcopyrite and molybdenite. Cobaltian arsenopyrite, pyrrhotite, chalcopyrite, quartz and tourmaline occur in the shear beyond the scheelite.

Spectrographic analyses of 30 specimens of wall and nearby rocks and of specimens of vein and rock minerals showed variations of the trace elements in groups in which the range in atomic radii was within the 15 per cent limit allowed by Goldschmidt in his rule for isomorphism of elements. Tungsten was absent in all the rock analyses; apparently it did not wander as a trace element into the wall rocks.

The scheelite ore occurs in 2 shoots where the shear cuts a 400-foot diorite sill but is not found where the shear cuts hornfelsed tuffs. The stress diagram of the vein-shear and related breaks shows that the 2 ore-shoots pitch in the same direction as the pitch of the intersection of potential tension openings within the vein.

The lenticular form, coarse to pegmatitic texture, and mineralogy of the tungsten vein imply formation at high pressure and temperature (the hypothermal class of veins). As a producing property, the Red Rose is unique in a class of scheelite deposits that does not ordinarily include commercial deposits of tungsten.

QUARTZ CRYSTALS WITH CLAY AND FLUID INCLUSIONS

STEPHEN TABER

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At several places in a narrow belt extending through Iredell, Alexander, Catawba, and Burke counties, North Carolina, quartz crystals with fluid and red-clay inclusions have been found. The rare and complex forms shown by the quartz, the inclusions of red clay, the large volume of water present in some cavities, and the presence of associated carbonate minerals, all indicate an origin not far from the surface under conditions of relatively low temperature and pressure.

Since the crystals with fluid-filled cavities are destroyed by freezing and since they are found close to the surface in areas that have suffered practically no erosion since the Pleistocene, it is concluded that soil in the upper Piedmont of North Carolina was not subjected to deep freezing during the glacial stages.

FROHBURGITE, FeTe_2 , A NEW MEMBER OF THE MARCASITE GROUP

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This new mineral was found associated with altaite, tellurbismuth, montbrayite, melonite, petzite, chalcopyrite, pyrite, marcasite, chalcocite, covellite, and free gold, in polished sections of the rich telluride ore from the Robb-Montbray Mine, Montbray Township, Abitibi County, Quebec. It appears in fringes surrounding chalcopyrite, also as inclusions in gold, petzite, or chalcopyrite. Color purplish pink, against the yellowish pink of melonite; reflection pleochroism not perceptible; anisotropism strong with polarization colors orange-red to inky blue; hardness C; negative to standard etch-reagents except HNO_3 (1:1) which etches black with strong effervescence. Micro-samples show only Fe and Te by chemical tests; and x-ray powder photographs give a pattern identical to that of FeTe_2 , the only known compound in the Fe-Te system, which was prepared for comparison by pyrosynthesis. Natural and artificial FeTe_2 give an orthorhombic unit cell with space-group $Pmnn$, $a = 3.85$, $b = 5.28$, $c = 6.26$, $Z = 2$, and observed intensities in good agreement with the marcasite-type of structure determined on FeTe_2 by Tengnér (1938). Named after Dr. M. H. Frohberg, mining geologist, Toronto.

PRE-FOUNTAIN WEATHERING ON FLAGSTAFF MOUNTAIN NEAR BOULDER, COLORADO

ERNEST E. WAHLSTROM

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On the slopes of Flagstaff Mountain near Boulder, Colorado, the Fountain formation, a conglomeratic arkose of Pennsylvanian probably post Des Moines age, rests unconformably on pre-Cambrian Boulder Creek gneissoid granite. A weathered zone approximately 90 feet in thickness and having many of the characteristics of a laterite lies beneath the unconformity and was formed prior to the deposition of the Fountain formation. A deep red, iron-rich rock at the top of the zone grades at depth into a mottled, light gray to pinkish gray, friable rock. This rock in turn, grades into fresh granite or, locally, into a brown-stained rock which has acquired its color as a result of recent weathering. The recent weathering has not affected the thoroughly decomposed rocks in the pre-Fountain weathered zone.

Chemical and mineralogical analyses of twelve samples of fresh and altered granite are presented in tabular and graphical form to show changes resulting from pre-Fountain and recent weathering.

ON THE GEOCHEMISTRY OF FLUORINE

B. WASSERSTEIN

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A semi-quantitative spectrographic method circumvents the chemical difficulty of obtaining much needed data on the distribution of fluorine in rocks. A systematic examination of South African rock-types has been undertaken to trace the sources of fluorine in underground waters, and so help those studying the incidence of endemic dental fluorosis, a disease attacking man and beast. About 250 spectrographic determinations have been made.

Fluorine appears to be a good indicator element for some petrological problems. As expected, marginal granites show high fluorine content (0.1 to 0.3%), whereas the centers of well eroded batholiths give low figures (0.05% and less). Bushveld felsites ($\pm 0.04\%$) contain less than their associated granites (0.1%). Investigation of sediments and soils has also increased our knowledge of the geochemical cycle of the element.

The conclusion is reached that fluorine is more common than is recognized and that the abundance figure accepted by present day authorities for the lithosphere, viz. 0.03%, should be doubled—and possibly trebled. This work has not yet been completed.

DISPERSION-BIREFRINGENCE RATIO AS A DIAGNOSTIC

A. N. WINCHELL AND W. B. MEEK

American Cyanimid Company, Stamford, Connecticut

The ratio between the dispersion of the birefringence ($B_F - B_C$) and the birefringence (B_D) is an optical property which is almost unknown; but it may be useful in certain cases. For example, a three (or four) component system may have physical properties such that "contour" lines for the commonly used physical characters, such as specific gravity, refringence, and birefringence, are all nearly parallel, but the lines of the dispersion-birefringence ratio seem to be far from parallel with the other lines in some cases. A few examples are given.

LUDLAMITE FROM NORTH GROTON, NEW HAMPSHIRE

C. W. WOLFE

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Ludlamite, hydrous iron phosphate, has been found as crystals in small veins in triphylite at the Palermo Mine, North Groton, New Hampshire. *Habit*: platy {001}. *Forms*: c{001}, a{100}, m{110}, l{011}, q{T11}.

X-ray data: Powder pictures of the Palermo material are identical with those of the type Cornwall material and of the Hagendorf, Bavaria *lehnerite*. Rotation and Weissenberg pictures about [010] and [001] give: Space group $P 2_1/a$; $a_0 10.48 \pm 0.06$, $b_0 4.63 \pm 0.05$, $c_0 9.16 \pm 0.06$, $\beta = 100^\circ 36'$; $a_0:b_0:c_0 = 2.26:1:1.98$. Analysis by Flight on type ludlamite gives irrational cell contents. From cell volume and $G = 3.08$ measured on one crystal $M_0 = 815.6$. If cell contents were $Fe_6(PO_4)_4 \cdot 6H_2O$, a molecular weight of 817.1 would be obtained, and this composition is tentatively assigned the mineral. An analysis of the Palermo ludlamite is forthcoming.

Opt.: Biaxial positive; $2V 80^\circ$; $\alpha 1.650$, $\beta 1.667$, $\gamma 1.688$. $r > v$ slight.

Occurrence: Transparent green crystals of ludlamite line narrow veinlets in triphyllite. Later minerals deposited in the cavities are, in order of deposition; *fairfieldite* in sheaf-like aggregates; vivianite in crystals coated with unknown white fibrous mineral; reddingite in orange brown crystals; stewartite (?) in platy orange brown crystals; and a biaxial white fibrous mineral with $2V$ about 80° , with positive optic sign, and with high birefringence, the indices ranging between 1.615 and 1.71. Only one specimen of the ludlamite has been found to date from Palermo, although another specimen from the Smith Quarry in Alexandria, New Hampshire, has been definitely established.

SPATIAL ORIENTATION OF URANIUM IN SAMARSKITE

HERMAN YAGODA

National Institute of Health, Bethesda, Maryland

Alpha ray patterns of polished samarskite sections prepared from crystals occurring in the Wiseman's mica mine, Mitchell Co., N. C. reveal marked variations of uranium content in symmetric growth zones which outline crystal faces. The polished sections appear to be optically homogeneous and show no evidence of foreign radioactive inclusions or internal alteration. Measurement of the photographic density of the alpha ray patterns show variations of about 25 per cent between zones of maximum and minimum blackening. Chemical analysis of the massive material reveals the presence of 0.8 per cent ThO_2 and 11.3 per cent U_3O_8 . Assuming a homogeneous distribution of the minor amount of thorium, the variation in photographic density indicates variations in the uranium content of extreme zonal layers ranging between 10 to 13 per cent U_3O_8 . Potential mechanisms for these unusual compositional variations are discussed.

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 1945 Adolf Pabst, Michael Fleischer, S. J. Shand, R. E. Grim
 1946 Michael Fleischer, S. J. Shand, R. E. Grim, Joseph Murdoch.

ANNUAL MEETING PLACES

- | | |
|-------------------------------|-------------------------------|
| 1920 Chicago, Illinois | 1934 Rochester, New York |
| 1921 Amherst, Massachusetts | 1935 New York, N. Y. |
| 1922 Ann Arbor, Michigan | 1936 Cincinnati, Ohio |
| 1923 Washington, D. C. | 1937 Washington, D. C. |
| 1924 Ithaca, New York | 1938 New York, N. Y. |
| 1925 New Haven, Connecticut | 1939 Minneapolis, Minnesota |
| 1926 Madison, Wisconsin | 1940 Austin, Texas |
| 1927 Cleveland, Ohio | 1941 Boston, Massachusetts |
| 1928 New York, N. Y. | 1942 No meeting held |
| 1929 Washington, D. C. | 1943 No meeting held |
| 1930 Toronto, Canada | 1944 No meeting held |
| 1931 Tulsa, Oklahoma | 1945 Pittsburgh, Pennsylvania |
| 1932 Cambridge, Massachusetts | 1946 Chicago, Illinois |
| 1933 Chicago, Illinois | |

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- Charles Palache, December 1937
 Waldemar T. Schaller, December 1938
 Leonard James Spencer, December 1940
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 Edward H. Kraus, February 1945
 Clarence S. Ross, December 1946

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- Naval Research Laboratory, Library, Washington 25, D. C.
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- New England Museum of Natural History, 234 Berkeley Street, Boston, Massachusetts.
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- O.I.C. Information Unit, American Embassy, Paris, France.
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 Philadelphia Mineralogical Society, Academy of Natural Science, Logan Circle, Philadelphia, Pa.
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- Royal Ontario Museum of Mineralogy, 100 Queen's Park, Toronto 5, Canada.
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PROCEEDINGS OF SOCIETIES

PHILADELPHIA MINERALOGICAL SOCIETY

The Academy of Natural Sciences of Philadelphia, May 2, 1946

Dr. W. Hersey Thomas presided, with 70 present. Dr. Edgar T. Wherry spoke on "The Radioactive Minerals of Pennsylvania."

June 6, 1946

Sixty-three were present, with Dr. W. Hersey Thomas in the chair. Dr. Joseph L. Gillson described the deposits of "Fluorspar in Mexico." The unusual geology of the Azul mine in the Taxco district evoked especial interest. The limestone hill at Rosario in Durango contains deposits of celestite as well as fluorspar, but not associated together. The mine at Parral contains a vein of fluorspar 39 feet wide, and accounted for a third of Mexico's production.

September 5, 1946

Fifty persons attended, while Dr. W. Hersey Thomas presided. Summer trips were reported by Mr. Rosensweig to Maine, by Mr. Arthur Boucut to Arkansas, the tristate lead-zinc area, and the Rocky Mountain regions; by Mr. Gordon to localities in Colorado, New Mexico, and the south; by Mr. Eisenberg to New England localities; and by Mr. Good to a number of western localities.

October 3, 1946

The 54th annual meeting was held with 67 present, and Dr. W. Hersey Thomas in the chair. Mr. Samuel G. Gordon addressed the society on "Desert Minerals," with examples drawn from the Atacama Desert, and areas in Arizona, such as the Mammoth mine. Mr. Arndt described a trip to New England.

November 7, 1946

Dr. W. Hersey Thomas presided, with 74 present. Dr. Earl Ingerson addressed the society on "Estimates, from Liquid Inclusions, of Temperatures of Formation of Vein and Pegmatite Quartz," descriptive of recent field experiences in Brazil followed by laboratory work in the investigation of vein occurrences, orientation of crystals in veins, and temperature and pressure of formation. Cavities filled or partially filled with solution are common in quartz crystals, and a microscopic study was made of the temperature at which (on heating) a bubble disappears: a temperature which can also be predicted from a measurement of the relative volume of bubble and liquid. More difficult was the estimation of the pressure prevailing on the liquid at the time of cavity filling. Kodachrome slides of quartz occurrences in Brazil, and data obtained from a study of the liquid inclusions were shown.

CHARLES A. BELZ, *Secretary*

NEW YORK MINERALOGICAL CLUB, INC.

American Museum of Natural History

Abstract of the Minutes of the New York Mineralogical Club for November 20, 1946.

The speaker of the evening was Professor Cornelius S. Hurlbut of Harvard University who spoke on "Modern Developments in Mineralogical Techniques." He described the usual methods of investigation that have been applied to minerals, but stressed the more recent refinements of techniques that enable more accurate measurements on smaller samples. Dr. Hurlbut referred to blowpipe reactions, specific gravity determinations, magnetic and electrostatic separations, infra red absorption, determination of indices of refraction, examination of polished sections of opaque minerals and several chemical methods involving micro-chemistry, spectrographic analysis and differential thermal analysis.

December 18, 1946

The principal speaker of the evening was Charles R. Toothaker, who spoke on "Recent Developments in Economic Mineralogy." Mr. Toothaker was associated with A. E. Foote, mineral dealer of Philadelphia, where he handled many specimens of all kinds. Mineralogists were familiar with the associations and the localities of minerals containing elements which at that time were considered rare and of no economic importance. However as uses for these elements were discovered there was a demand for them in quantity and manufacturers had to rely on mineralogists either to supply them from known localities or to find new occurrences.

January 15, 1947

The speaker of the evening was Dr. Edgar T. Wherry who spoke on "Searching for Radioactive Minerals in Pennsylvania." He found that there were quite a few radioactive minerals in Pennsylvania, mostly in southeastern Pennsylvania, but none in large amounts. Some of these minerals are autunite, torbernite, euxenite, allanite and cyrtolite.

However an important deposit of carnotite was found at Mauch Chunk where the mineral is scattered through a coarse sandstone. It is believed that plants were responsible for the concentration of the elements of this mineral which accumulated in the rock.

PURFIELD KENT, *Secretary*

BOOK REVIEW

IDENTIFICATION AND QUALITATIVE CHEMICAL ANALYSIS OF MINERALS
by ORSINO C. SMITH. D. Van Nostrand Company, Inc., ix+351 pages (1946). Price \$6.50.

In 1940 the author published a handbook of minerals under the title "Mineral Identification Simplified." This earlier text of 271 pages listed over 2000 minerals and consisted essentially of tables based largely on the two important physical properties of specific gravity and hardness (reviewed in *Am. Mineral.*, **25**, p. 767).

The present enlarged text of 351 pages, while based on the same underlying principles as the earlier work, has a number of innovations which are aimed to assist the student in the identification of minerals. In this expanded edition, under a new title, greater stress is placed on wet qualitative tests of the elements, including many of the rare earths, to supplement the strictly blowpipe reactions and the physical properties.

It seems that an unnecessarily large amount of space (about 20 pages) has however been devoted to detailed instructions for constructing "home made" balances for specific gravity determinations and a chemical "portable laboratory" for field work.

Perhaps the most unique feature of the book is the very large number (20 pages) of colored illustrations which attempt to depict the natural color of minerals, the reactions on charcoal, plaster tablet, bead tests and the appearance of a few minerals when exposed to ultra violet light. Some of these colored plates are without question very good and should prove extremely helpful; however many are of questionable merit.

As the book covers a wide field of mineralogic information including both the chemical and physical properties it should prove a very handy reference manual for the mineralogist, geologist and chemist.

W.F.H.

NEW MINERAL NAMES

Pennantite

W. CAMPBELL SMITH, F. A. BANNISTER AND MAX H. HEY, Pennantite, a new manganese—rich chlorite from Benallt mine, Rhiw, Carnarvonshire. *Mineralog. Mag.*, **27**, 217–220 (1946).

CHEMICAL PROPERTIES: Formula probably $(\text{Mn}, \text{Al})_{12}(\text{Si}, \text{Al})_8\text{O}_{20}(\text{OH})_{16}$, analogous to thurginite. Analyses: 1. on 30 mg. of pure material; 2. on 40 mg. of material containing appreciable banalsite and opaque manganese minerals.

| | SiO_2 | Al_2O_3 | Fe_2O_3 | MnO | MgO | BaO | H_2O | Sum |
|----|----------------|-------------------------|-------------------------|--------------|--------------|--------------|----------------------|-------|
| 1. | 22.64 | 18.60 | 4.43 | 38.93 | n.d. | 1.33 | n.d. | |
| 2. | 23.43 | 18.76 | 6.80 | 32.46 | 1.48 | 7.40 | 9.40 | 99.73 |

Calcium and titanium were tested for and not found; alkalis were not determined. Neither ferrous iron nor trivalent manganese was found to be present.

X-RAY STUDY: X-Ray powder photographs are identical in pattern with those of thuringite. Cell dimensions $a=5.43$, $b=9.4$, $c'=28.5$ Å. Cleavage good.

PHYSICAL AND OPTICAL PROPERTIES: Color orange-brown. Optically uniaxial, negative, $n_s(\text{Na})\alpha=1.646\pm.001$, $\beta=\gamma=1.661\pm.001$. Absorption $\alpha<\beta<\gamma$. Pleochroic with γ' (parallel to cleavage) xanthine-orange, α' orange-buff. $D_4^{16}=3.06\pm.01$.

OCCURRENCE: In patches and small flakes in the matrix, less commonly in the ore and in thin veins cutting the ore. The vein from which material for analysis was obtained contained chiefly paragonite and analcime, with minor amounts of banalsite, ganophyllite, tephroite, and pyrophanite.

NAME: For Thomas Pennant (1726–1798), Welsh traveller, zoologist, and mineralogist.

MICHAEL FLEISCHER

Calclacite

RENÉ VAN TASSEL, Une efflorescence d'acetatochlorure de calcium sur des roches calcaires dans des collections. *Bull. musée royal d'Histoire naturelle de Belgique*, **21**, No. 26, 11 pp. (1945).

The name calclacite (from the chemical composition) is given to the compound $\text{CaCl}_2 \cdot \text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 10\text{H}_2\text{O}$, which formed efflorescences on certain calcareous rocks stored in wooden cases. Physical, chemical, optical, and thermal data are given. As the same rocks when stored in glass showed no formation of efflorescences, Van Tassel concludes that the acetic acid was probably derived from the wood, hence that this is not a mineral in the strict sense.

M.F.

Goldfieldite

R. M. THOMPSON, Goldfieldite = tellurian tetrahedrite. *Univ. Toronto Studies*, Geol. Ser. No. **50**, 77–78 (1946).

X-ray and microscopic study of material from Claremont mine, Goldfield, Nevada, showed that it was a mixture of tetrahedrite, bismuthinite, and famatinitite. Only the tetrahedrite gave a microchemical reaction for Te. Goldfieldite is therefore a tellurian tetrahedrite.

M.F.

Haringtonite

N. W. WILSON, Geology of the Monarch cinnabar mine, Transvaal, South Africa. *Bull. Institution Mining and Metallurgy* (London) No. 470, 1-24 (1945).

This name, for the locality Harington Kop, is given to a mercury mineral resembling cinnabar and guadalcazarite (=zincian metacinnabar). It occurs intergrown with, and apparently replacing cinnabar, also in intergrowths with gold. Color blackish-red, luster sub-metallic, and streak cinnabar-red. Under the microscope it is light-gray with red internal reflections. It is soft, anisotropic and has low relief. Spectrographic study of doubtfully pure material shows traces of Cu, Zn, Sn, Sb, and As.

DISCUSSION: It has been pointed out repeatedly that the literature should not be burdened with new names on the basis of so little evidence. If there must be a tag for such material, why not call it "Unidentified mineral A" until it has been proved to be worthy of a name?

M.F.

Ondřejite

JAN VÁCLAV KAŠPAR, Ondřejite, a new mineral. First preliminary note. *Veda Přírodní Praha*, 23, 132-137 (1944) (in Czech); through *Mineralog. Abs.*, 9, 261 (1946).

Crusts and irregular concretions recently found on prismatic crystals of aragonite in the Zbrašov caves near Hranice in eastern Moravia consist of white pulverulent material, the homogeneity of which was proved by x-ray photographs. $G=2.217$; analysis gave: CO_2 43.50, SiO_2 6.57, FeO 0.46, MgO 18.34, CaO 12.65, Na_2O 8.31, H_2O (60°) 2.07=94.07. If this deficit represents water expelled at a still higher temperature, the mineral would belong to the thaumasite group."

M.F.

Kribergite

TORSTEN DU RIETZ, Kribergite, a new mineral from Kristineberg mine, Västerbotten. *Geol. För. Förh.*, 67, 78-79 (1945) (in Swedish), through *Mineralog. Abs.*, 9, 188 (1946).

"A white, compact, chalk-like mineral filling crevices in pyrite gave on analysis by B. Helger P_2O_5 31.27, SO_3 13.05, Al_2O_3 38.45, MgO 0.02, V 0.003, H_2O 17.22=100.01; agreeing approximately with $2\text{Al}_2\text{O}_3 \cdot 2(\text{P}_2\text{O}_5, \text{SO}_3) \cdot 5\text{H}_2\text{O}$. $G=1.92$, $n=1.484$, $\gamma-\alpha$ about 0.002, but variable. Under the microscope it shows a felted lamellar to spherulitic structure. X-ray powder photographs show five weak lines indicating a low degree of symmetry."

M.F.

Kyanophilite

B. RAMA RAO, 'Kyanophilite'—a new mineral of the hydrous aluminum silicate group derived from kyanite, from Mavinhalli, Mysore. *Current Sci. Bangalore*, 14, 196 (1945); through *Mineralog. Abs.*, 9, 188-189 (1946).

"Loose lumps of an apple-green mineral, resembling talc or chlorite in appearance, were found in an area of kyanite-graphite-schist. Thin sections show plumose aggregates with $n=1.58-1.60$ and low birefringence. Analysis gave: SiO_2 45.20, Al_2O_3 41.04, MgO 0.0, CaO 3.72, Na_2O 3.84, K_2O 0.73, ignition (mostly water) 5.00."

M.F.

The annual meeting of the Society for Experimental Stress Analysis, including a Symposium of Shock and Impact, will be held at The Stevens Hotel, Chicago, Illinois, on May 15, 16, and 17, 1947. Inquiries should be addressed to the Society of Experimental Stress Analysis, P.O. Box 168, Cambridge 39, Massachusetts.

NOTES AND NEWS

BOOKS AND WORLD RECOVERY

The desperate and continued need for American publications to serve as tools of physical and intellectual reconstruction abroad has been made vividly apparent by appeals from scholars in many lands. The American Book Center for War Devastated Libraries has been urged to continue meeting this need at least through 1947. The Book Center is therefore making a renewed appeal for American books and periodicals—for *technical and scholarly books and periodicals in all fields* and particularly for *publications of the past ten years*. We shall especially welcome complete or incomplete files of *The American Mineralogist*.

The generous support which has been given to the Book Center has made it possible to ship more than 700,000 volumes abroad in the past year. It is hoped to double this amount before the Book Center closes. The books and periodicals which your personal or institutional library can spare are urgently needed and will help in the reconstruction which must preface world understanding and peace.

Ship your contributions to the **American Book Center, c/o The Library of Congress, Washington 25, D. C., freight prepaid**, or write to the Center for further information.

Dr. G. Aminoff, professor of Mineralogy and Director of the National Museum in Stockholm since 1923, died February 12, at the age of 63 years.